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METHODS OF BREEDING HERBAGE PLANTS BASED ON GROUP VARIABILITY*

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(Translated from Russian)

THE methods of breeding herbage plants are very diverse, as they depend upon the use for which the plants are intended, upon the large number of species of plants with a wide range of variation in biological properties and upon the amount of time to be devoted to their breeding. It is now, in fact, impossible to speak of breeding methods without reference to those processes of breeding for which they are intended, as the uniform and unspecified breeding of the past has now been differentiated into distinct phases, each with its own technique. Modern breeding virtually comprises the following phases :

(1) procuring adequately diverse initial material to satisfy the requirements of a breeder ;
(2) valuation and choice of the progenitors (basic plants) from which a variety is to be built ;
(3) building up varieties of agricultural value with definite properties ;
(4) multiplication of material ;
(5) valuation of the variety built up and its possible regional distribution.

These processes may be so closely interlocked that it is not always easy to say when one of them begins to prevail over the others. At each of the phases enumerated, however, its special problems are solved by different methods. With reference to those principal changes which occur in the hereditary basis of the basic plants during strain building, the diverse methods of building strains can be brought under the following three groups.

In the first group of methods the hereditary base of the progenitors is impoverished ; this embraces inbreeding, whether natural or otherwise, and various methods of closely related reproduction, such as intercrosses between brother and sister plants.

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The second group tends to retain the hereditary base of the chosen basic plants unchanged ; this includes the methods of clones and pedigree lines.

In the third group the hereditary base is enriched, as in different methods of hybridization, such as restricted pollination, for example, in diallel crossings, or the free interpollination common in simple family selection, or in Lysenko's intravarietal crossing of self-pollinated plants.

All these methods only partly make use of the concepts of general and special genetics and hardly touch the advances made in the systematics, biology and physiology of herbage plants. The breeding of agricultural plants is based upon the hereditary variability of the species being bred, formed during evolution and consequently bearing characteristic properties of their past and present evolution. In each species we find individual minor quantitative hereditary changes arising and accumulating in the course of evolution ; as a result of their various groupings and the ever-increasing discrepancies between them, greater differences arise within the species as qualitatively different more or less large natural-historical forms. Each of these forms represents a step in the group differentiation of a species and in reality is a natural fractional, taxonomic unit, all plants having followed a similar historical course in their genesis and consequently having common fundamental hereditary properties or characters side by side with smaller, more individualized differences. These minor hereditary differences occur in one or a few plants and are generally inherited without linkage, that is, they belong to individual variability. Some more common groups of properties and characters of these forms belong to all the plants of a form and are transferred through heredity in the shape of similar complements, that is, this type of variability is virtually a group variability.

In the present state of our knowledge, individual variability can be regarded as the genotypical variability studied by genetics, a biotype being the representative of this type of variability. With reference to the prevalence of the type of variable character, group variability may be classified as :

(a) systematic (polymorphism), studied in systematics of plants, such as prolese, subspecies, variety, and other botanical forms ;

(b). ecological, studied in ecology, such as climatypes and other ecotypes ;

(c) biological (including physiological), as yet little studied, such as natural (indigenous) and local (cultivated) varieties or populations, and physiological forms, e.g. winter and spring, annual and perennial, short and long-day groups.

The first two types differ markedly from the third ; the grouping of plants in the former types is largely based upon qualitative systematic characters, morphological characters and upon characters of importance in the adaptability of plants to the habitat ; for this reason plants comprising forms of group variability of an ecological and particularly of a systematic order can be readily distinguished by their external habitus. On the contrary, plant groups of biological variability differ mainly, and in some cases, exclusively in physiological characters. In the terminology of plant breeders this embraces types, populations of various origins and indigenous varieties ;

some breeders also refer ecotypes to this group, meaning thereby a group of biotypes within a species which have some common hereditary characters adapted to a micro-climate, micro-relief, etc., that is, groups formed under natural selection or unconscious biological or economic selection. As distinct from ecotypes of the botanical order these so-called micro-ecotypes frequently do not differ one from another, except in minor characters. When the forms are split into a number of types (groups of biotypes) interrelated by some common hereditary characters, and these types are adapted to different geographical habitats they are known as geographical types.

All the enumerated types of group variability are not sharply demarcated, each overlapping the other, and as a rule only that inner property which characterizes the type of variability is most expressed. In some cases it is difficult to say which of the types is being dealt with, particularly because hereditary variability is frequently masked by modification. However, not a single case is known in which at least two of the group variabilities are not operating at the same time. It is in fact impossible to think of two subspecies of the same species which, while differing externally, show no difference in biological characters. This would be contradictory to the theory of natural selection and the origin of subspecies, as well as every-day observations.

In practice, the choice of progenitors has been based almost exclusively upon individual hereditary variability, despite the fact that species of herbage plants are from a breeding point of view of very recent origin and have a rich diversity in the wild flora, as well as among local varietal populations. In the face of this fact, the wealth of natural-historical forms would make selection by entire forms of group variability more efficient. Theoretically, the efficacy of selection by those forms has the following premises :

(1) Natural-historical forms of a species arose as a result of evolution forming more and more adapted and superior organisms.

(2) As a result of the discrepancy of characters in evolution, the greater the taxonomic units to which they belong, the greater are the differences between the representatives of the same species.

(3) A correlation has been established in agricultural practice between biological and morphological characters of group variability within a species and its economic properties.

Research on the efficacy of selection by forms in herbage plants was begun by the author in 1924 and tested on various species. The comparison of various methods of selection was made according to the following scheme. (a) From the *same* initial material, (b) basic plants were selected by *different* methods, (c) from which strains were built by *similar* methods, and (d) later compared under similar conditions.

In 1924-1927 the author, and later V. D. Ščerbačeva, studied selection by types in Sudan grass. As a matter of course seven types were established within the initial material with distinct differences as regards shape of grain, panicles, height, tillering vigour, weight, cross section of stem, etc. The adequately distinct expression, demarcation and stability of the morphological and physiological differences between

these types seem to confirm the efficacy of selection from Sudan grass, in the first place, by those types as actual fractional units of the species. As selection by types was made concurrent with selection of a few plants from each type, an individual selection was also made for the sake of comparison. The comparative study showed that the best results and the fullest inheritance of characters were observed in selection by types, notwithstanding the fact that this selection resembled, as it were, a mass selection which is indeed less effective than individual selection.

TABLE 1.—Inheritance of height and weight in selection by individuals and types in Sudan grass (1924-27).

Individual selection				Type selection				
Mean weight of a plant in grm.		Mean height of a plant in cm.		Initial	Mean weight of a plant in grm.		Mean height of a plant in cm.	
Parents	Progeny	Parents	Progeny	Type	Parents	Progeny	Parents	Progeny
80–100	146	130–140	224	I	100	165	165	205
100–120	216	140–150	238	II	135	125	150	190
120–140	175	150–160	203	III	150	150	165	205
140–160	161	160–170	205	IV	150	150	160	200
160–180	156	170–180	209	V	140	140	160	200
180-200	148	180-190	229	VI	195	225	175	210
200–220	139	190–200	221	VII	250	300	185	235

Table 1 shows that the individual characters of the progenitors had little effect on the progeny, whereas the type characters were well inherited. Further descriptions confirmed good inheritance in some other characters, such as vigour of tillering, type of seed, width of leaf and cross section of stem, except in the first type in which there was a discrepancy in weight between the initial type and the progeny. This could be explained, however, by a special response of this type to the rate of seeding.

In 1932 Ščerbačeva applied selection by type (in the form of subspecies) to spring vetch at the former Ukraine Institute of Fodders, Poltava. Populations of the indigenous vetch were grouped before sowing by the type of seed under eight subspecies, which were immediately tested with some 22 varieties bred at various stations by different methods. As the selected subspecies were the product of a large number of pure lines and the selection resembled a mass selection, they might have been expected to be inferior to good pure lines. In 1932-1933, however (Table 2), at least two of the eight types took first place in total yield. That is to say, in one year by selection of types two varieties were formed superior to the pure line, No. 134, the best of the varieties tested and a product of many years work; in other words, quite inexplicable results were obtained from the ordinary point of view,

TABLE 2.—Varietal test of spring vetch.

Variety	Hay yield of vetch alone (centn. per ha.).			Grain yield (centn. per ha.)	Sum of places by order
	Hay	Proteins (per centn.)	Proteins (per cent)		
2514 var. *affinis* Ted. ..	26.3	25.7	5.7	7.7	14
2516 var. *atomaria* Ted. ..	27.4	23.6	5.4	7.9	16
Kievskaja	25.5	23.1	5.1	9.1	16
134 Harjkovskaja	28.3	23.3*	7.3*	7.1	19
2519 var. *pseudo immaculata* Helm	23.6	23.7	4.7	8.7	29
2513 var. *variabilis* Ted. ..	26.2	22.4	5.0	6.2	31
2512 var. *typica* Ted. ..	25.5	22.9	4.9	7.2	31
Kurskaja	24.4	22.5	4.6	8.5	34
Gluhovskaja	21.8	23.1	4.6	8.4	38
2519 var. *immaculata* Ted. ..	24.2	21.0	4.2	6.8	42
Indigenous Poltavskaja ..	24.0	22.2	4.5	7.1	42

*Only for one year (1932 harvest) when this line took one of the first places in yield of crude protein.

For comparison, mass selection was also applied to some groups of plants from the same population ; as would be expected, mass selection had no effect.

An attempt to apply selection by types in red clover breeding was made by the present author in 1927. Investigations showed that there exist in red clover winter and spring forms which could readily be distinguished in some years in the southern nurseries. Some results of selection of these forms from early and late clovers and of the subsequent test of their winter hardiness when planted singly in nurseries in the winter of 1927-1928 are given in Table 3.

TABLE 3.—Winterhardiness in various forms of red clover.

Form	Number of wintering plants	Number of plants which survived by the spring	Percentage mortality
Winter late	435	426	2.1
Spring late	2232	1605	28.1
Early	1632	967	42.5
Spring early	62		100.0

Increased winter hardiness in the selected winter forms of single cut clover is just as evident as low winter hardiness in the spring forms of double cut clover, that is, by selecting typical winter forms from single cut clover one might hope to build a more winter-hardy variety. In 1930, these and some pedigree lines were tested on a large scale, the yield being recorded in the year of sowing. A curious fact was revealed, namely, in spite of simultaneous cutting, spring late forms yielded conspicuously more than the typical early clover from Nosovka, winter late forms giving no stem at all. This suggests the advantage of using selection of spring and winter forms ; the theory of phasic development as applied to red clover will give us some practical methods of splitting populations into spring and winter plants.

The study of numerous natural-historical forms in herbage plants showed that selection of natural strains can most readily be effected in the early stages of work with the species. In tests of various samples of wild grasses, the best natural strains were superior to the standard bred varieties. For instance, at the Experimental Farm, Morshansk, in 1935 three strains of *Festuca pratensis* were above standard ; No. 560 showed a 10 per cent increase in yield and 5 per cent in leafiness, No. 134 showed 45 per cent increase in yield and 19 per cent in leafiness, while No. 133 showed a 50 per cent increase in yield and 9 per cent in leafiness. Varietal tests at the Institute of Fodders showed that high quality forage may be obtained from these natural strains. In a comparative study of *Festuca rubra* some wild samples from the Gorky (Nizhni Novgorod) Region were best as compared with the cultivated.

A good valuation was also given to some natural strains of *Dactylis glomerata*, for example, at the North Caucasian Station the indigenous wild type gave a yield 150 per cent higher than the cultivated strains ; and a sample entered as No. 61 was superior in yield and winter hardiness to all strains tested at the Experiment Station, Tursk. Some strains of wild *Agropyron* gave yields 20 per cent higher than any cultivated strains tested on some southern farms.

This brief account shows that selection by forms must take an appropriate place in breeding schemes for herbage plants and that this method should also be closely studied even in work with self-pollinating plants, as in some cases selection by forms gave better results than the pure line method.

The efficacy of type selection can be explained by the fact that here we are actually making use of a large hereditary group variation, the hereditary basis common to all the plants of the same form. The main advantages of type selection can be summarized as follows :

(1) By selecting many plants of the same form the breeder obtains a large amount of seeds enabling him (a) to conduct early and accurate varietal tests, including a preliminary test on small plots, (b) to reproduce a variety rapidly, and (c) to expedite the process of strain-building.

(2) As the variety obtained by this method is a population it will generally be of wider adaptability than a pure line and hence its regional distribution may be more readily effected, saving many years' varietal tests in a number of places.

(3) A single selection by types is as effective as individual selection in self-pollinating plants.

(4) Selection by forms facilitates the broad use of natural selection, advances in systematics and plant physiology, while the technique of selection is not complicated.

In addition to the methods commonly employed in building strains others were studied in work with populations, namely, free inter-varietal crossing and restricted inter-varietal crossing. The method of free inter-varietal crossing was studied by the author on red clover in 1927-1930 at the Experimental Station, Nosovka. Some varieties sown annually for a preliminary varietal test were kept under observation and their yield recorded for two or three years; in the third year of the ley, when the poorest plants had disappeared, all the clover plots were left for seed. Seeds were collected from the best of these for a further varietal test. The main feature of this method is that artificial selection was added to a natural selection and at the same time a synthesis was effected in order to build up a new superior variety through the free interpollination of the most persistent plants concerned. Insofar as clover had been dealt with, we intended to increase the stability of clover yield and winter hardiness. The varietal tests of the samples thus obtained gave in 1930 (first year of ley) the results shown in Table 4.

TABLE 4.—Efficacy of free inter-varietal crossing in red clovers.

Selected sample	The set from which selection was made	The origin of the sample selected	Hay yield per cent
Control	—	Nosovka	100.0
,, ...	—	Kursk	102.0
No. 4	II	Nosovka	106.5
No. 7	IV	Nosovka	109.3
No. 11	I	Nosovka	111.3
No. 9	II	Nosovka	112.2
No. 29	I	Minsk	118.1
No. 34	I	Malmyzh	157.5

A single selection gave very interesting results in some cases. For example, a cross pollination of the intermediate type from Malmyzh with early and late clovers gave offspring with a very intense rate of development in the first year. It is of interest also that different sets of varieties had their own effect on the efficacy of inter-varietal crossing. Thus, the mean yield of all the samples selected after free interpollination from the first set is 124.4 per cent, from the second 99.9 per cent, from the third 95.6 per cent and from the fourth 101.3 per cent, as compared with

the standard. The best samples were obtained from the first set in which there was a small number of varieties tested (about 30) and which had passed through a very severe winter and good selection for immunity to anthracnose ; the mean yield of the best samples reached 100 to 150 d. centn. per ha. in the first and second year owing to the high soil fertility.

It may be assumed that an appropriate choice of types for inter-crossing, a good vegetative season and the restriction of inter-varietal crossing to a definite set of varieties would have given better results than free inter-varietal crossing.

Restricted inter-varietal crossing was studied by the author on red clover in 1927-1930. For this purpose three clovers from Nosovka, Poltava and Tula were intercrossed ; in order to evaluate the efficacy of this type of inter-varietal crossing, a mass selection was made from the original Nosovka clover. The test comprised only the seeds obtained from the Nosovka clover pollinated by the other varieties, that is, the varietal populations given in Table 5 as No. 1, and a mass selection from

TABLE 5.—Comparative yield of clover ; mean values for 1929-30.

Origin of clover	Hay yield		Origin of clover	Hay yield	
	d. centn. per ha.	per cent.		d. centn. per ha.	per cent.
Mass selection ..	23.8	107.1	No. 1	52.1	141.9
Nosovka ..	22.0	100.0	Nosovka	36.8	100.0
Tula	16.0	72.6	Tula	28.9	78.6

the Nosovka clover. The selected samples (from the mass selection and from the inter-varietal crossing), thus compared with the two initial varieties, gave for two years of the test the result shown in Table 5.

Judging by these data, inter-varietal crossing deserves careful study and application to the breeding of cross-pollinating plants. It is possible thereby to effect a single, double, or multiple crossing of two or many varieties and a simple reproduction of hybrids or combination of this method with some other methods of strain building. These preliminary data on the efficacy of inter-varietal crossing in clover were confirmed by some incidental data obtained in the breeding of fodder roots (inter-pollination between fodder and sugar beets) and some other plants.

The main advantages of the method of inter-varietal crossing are as follows :—

(1) selection and evaluation of a variety are carried out under ordinary farming conditions and the plant breeder avoids those difficulties connected with the evaluation of plants in a nursery ;

(2) artificial selection is here combined with natural selection and in the process of systematic crossings of the best forms good agricultural properties of many varieties are accumulated and united in a variety ;

(3) in inter-varietal hybridization the plant breeder makes full use of the results of the evolution and natural selection which have created special distinct forms of plants, and also he uses heterosis, when this has occurred ;

(4) as both the minor hereditary changes of individual plants and the larger and more constant group changes are used in breeding, the degree of success will naturally be higher ;

(5) as from the start there is a large amount of seeds of each variety, the whole breeding work is considerably accelerated.

The method of selection by types and inter-varietal crossing is particularly applicable to herbage plants, as even a marked lack of uniformity in a variety is not particularly inconvenient from an agricultural point of view. At the same time, with an appropriate choice of varieties, this method is quite applicable to some other plants.

REVIEWS

EXPERIMENTAL STUDY OF ALPINE VEGETATION

[Reviewer: G. M. Roseveare.]

A reserve was set apart in 1927 for the study of alpine vegetation on the Schinige-platte, near Interlaken. Since that date it has been free from grazing and the visits of tourists. Certain areas representative of the principal plant associations are kept permanently free of all cultural treatment. Other typical areas have been used for experiments designed to ascertain the effect of various forms of treatment, and these experiments are described by Werner Luedi of the Geobotanisches Forschungsinstitut Rübel, Zürich, in *Ber. Schweiz. bot. Ges.* 46. 632-81. 1936, with ten photographic illustrations. They were in progress from 1928 to 1934, and it is noted that they are of a preliminary nature and that since 1931 the investigations have been continued on a much larger scale on experiment pastures in the same vicinity. The associations concerned are (1) Nardetum, or poor grassland dominated by *Nardus stricta*, referred to as "heath meadow"; (2) Festucetum rubrae commutatae, referred to as "fresh meadow"; and (3) Seslerieto-Semperviretum, referred to as "dry meadow" on lime. The size of the plots was one square metre, with a border 30 cm. wide. The majority were laid down in the Nardetum, but in the Festucetum there were some smaller additional plots. Most of the experiments were carried out in duplicate.

The various forms of treatment were as follows. (1) Nardetum: regular mowing of the sward; full manuring without lime; liming; removal of the plants which were indicators of poor land, with and without full manuring minus lime; removal of the sward by shallow scaling, followed by natural re-colonization; removal of the sward accompanied by deep tillage and careful removal of all fragments of rhizomes; the same treatment plus resowing (with Festucetum species or mixture of Festucetum and Nardetum species), with and without subsequent manuring.

(2) Festucetum: regular mowing; stamping of one half of the plot (to simulate trampling, once yearly); planting with young plants from the Nardetum, Festucetum and Seslerieto-Semperviretum swards; sowing of a Nardetum, Festucetum, or Nardetum plus Festucetum seeds mixture, with and without manuring.

(3) Seslerieto-Semperviretum: full manuring without lime; removal of the sward and natural regrassing; removal of the sward and resowing with Festucetum or with Seslerieto-Semperviretum species, in the first case combined with full manuring without lime.

Results in the Nardetum.

Regular mowing without manuring maintained the old sward practically unaltered: on the other hand a change—in the Festucetum direction—is recorded in the unmown control. Full manuring without lime transformed the Nardetum in an extremely short time into a dense and tall fresh meadow, poor in species but productive, of the Agrostideto-Festucetum rubrae commutatae type, if, as here, a few representative Festucetum species, however poor as individuals, were present. Liming produced a low but very dense sward of the "fresh meadow" type with an abundance of Leguminosae, but the grasses fruited relatively little. Yield was of medium proportions. The removal of plants indicating poor land produced, without manuring, a poor "fresh meadow" which gave very little yield and was in course of retrogression to Nardetum. If manure was applied, development took the same course as under full manuring. By the scaling of the sward, the complete elimination of *Nardus* and of the majority of the other indicators of poor land was obtained. From parts of rhizomes left in the soil there developed new plants, principally of *Plantago alpina* and of several fodder grasses (*Agrostis capillaris*, *Phleum alpinum*, *Festuca rubra*). Of the Nardetum species *Campanula barbata* alone was practically uninjured. A new plant cover was quickly formed which contains the nucleus of a "fresh meadow." The individuals, however, remain of dwarf growth; without manuring there is no development into a productive meadow, but rather a retrograde tendency. Even after six years no perceptible yield was obtained. Scaling together with tillage is followed by a slow and gradually progressive natural regrassing. The final product is as in the case previously mentioned; but through tillage the development of more vigorous individuals and therewith of productivity seems to be promoted, at all events temporarily. The sowing of a Festucetum seeds mixture or a Festucetum plus Nardetum mixture produces exactly the same result. In each case there arises first a "fresh meadow" sparsely composed of acidophilous species with a practical absence of *Nardus*. Basophilous species which were sown down did not come up at all. Even after the passage of six years the sward has not emerged beyond a dwarf stage and gives no yield, and indicators of poor land are slowly beginning to spread again. If sowing is combined with manuring, the plant cover makes its appearance much more rapidly; a tall and productive Agrostideto-Festucetum develops, at the outset, however, poor in species.

The alterations which take place in the soil in consequence of the land being used no longer and on account of the experiments, are not unimportant. Acidity has remained practically the same, even in the areas where there is full manuring without lime. Only when carbonate of lime was used was there a slow but steadily increasing reduction of acidity.

Results in the Festucetum.

Mowing without manuring has certainly produced within the period of experimentation a perceptible decrease of yield, but there is as yet no impoverishment; the sward appears to possess a great power of resistance to deterioration. The

stamping down of the sward (to simulate trampling) produced in the stamped halves of the plots a lower and denser sward, in which the proportion of grass haulms is greatly reduced, but on the other hand *Trifolium repens*, *Ligusticum mutellina*, *Plantago alpina*, *P. montana*, *Crepis aurea* and *Leontodon hispidus* are more frequent. Actual deterioration of the sward is therefore not observed ; but yield is perceptibly lower than in the untreated half. A physical study of the soil discloses a considerable reduction of permeability in the same half. In addition, the water content has become greater, and the air content less. These alterations must result from reduction of the soil pores in consequence of stamping. Young plants planted out into small experiment plots maintained their position, but without any marked tendency to spread. The sward closed up very slowly, partly through considerable growth on the part of the individuals planted in, and partly through the migration of plants in the neighbourhood, which once more form the nucleus of a " fresh meadow." Correct planting-in is no easy matter. In the experiments the individuals were probably planted too sparsely ; the choice and the relative proportion of the individual species within the association type are probably also of importance. When Nardetum and Festucetum seeds mixtures are sown down, only the Festucetum species become established. The Nardetum species are lost, so that in combination with natural volunteering there is formed a " fresh meadow " which without manuring remains of poor, low growth (*Leontodon hispidus*, *Plantago alpina* and *P. montana* dominant), but with manuring develops into a tall, close grass sward (*Festuca rubra commutata* dominant, occasionally also *Agrostis capillaris* and *Trifolium repens*). (Quadratic plots with 30 cm. sides and 20 cm. borders were found to be too small for such experiments.)

Results in the Seslerieto-Semperviretum.

Manuring without lime results in a luxuriant development of *Festuca rubra commutata* and *Phleum Michelii*, which is accompanied by a considerable retrogression in various of the Seslerieto-Semperviretum species. This is probably to be attributed not only to the direct action of manuring (see below), but in part to shading and root competition on the part of the more vital grasses. There arises a sort of transitional stage between Seslerietum and Festucetum. The natural development of the vegetation, when the old sward is removed and the soil is dug up, is a direct retrogression to Seslerieto-Semperviretum. But it takes place at first very slowly, and the only pioneers are the herbs of the Seslerieto-Semperviretum. Particularly prominent on account of their capacity for rapid spreading are *Silene inflata* and *Arabis corymbiflora*. Thus there arises first a herb stage. The grasses do not appear for several years, and they then sprout up generally among the herbs or under stones, gradually increase in vigour and suppress the herbs, the above-named pioneers included. At this stage the pace of development is more rapid ; but even after six years areas of considerable size may be bare. If after removal of the old sward and digging up the area, it is also sown down, the development of plant cover is certainly accelerated, but follows exactly the same course. The

grass seedlings all dry up, and only later, profiting by the pioneer work of the herbs, do they make their appearance in the same way as has been described above. It is always a Seslerieto-Semperviretum which is formed, quite independent of whether a " dry meadow " or a " fresh meadow " seeds mixture has been sown down. Manuring accelerates the rate, but does not alter the course of development. The dominant Seslerieto-Semperviretum species are not driven away by manuring. The proportion of Festucetum species in the new sward continuously decreases. Thus the effect of manuring is even less than it was in the old Seslerieto-Semperviretum sward, probably because it is impossible for the grasses to exist. Only later, when the grasses have begun to spread, is it possible to expect manuring to give a similar result to that recorded above in the case of the old sward.

Some General Results.

The deterioration of the alpine pastures on the Schinigeplatte, which on level or slightly sloping land with a sunny aspect has led to the dominance of *Nardus* or to the formation of a Nardetum, can easily be corrected by manuring. In place of the poor grassland there is then formed a fresh meadow of the Agrostideto-Festucetum rubrae commutatae type. The direct production of a Nardetum, whether by sowing down or through the natural regrassing of a scaled area, was never successful, either on a Nardetum soil or on a Festucetum soil. There was always formed first of all a fresh meadow, even if it only consisted of dwarf grasses (when manuring was omitted). Several other acidophilous species and indicators of poverty, such as *Campanula barbata, Gentiana Kochiana, Arnica montana, Luzula multiflora, Carex pallescens,* and *Potentilla aurea,* seem to be able to colonize new land and to become established before *Nardus*. Within six years *Nardus* has not been able to establish itself to any material degree in any one of the regrassed plots.. On the other hand, in old sward it can make its appearance again after it has been dug out, and spread comparatively rapidly, perhaps in part from the remains of old tufts. The Nardetum of these poor, humus-deficient slate soils is clearly not the close sward of the primary vegetation proper to the locality ; this is rather to be seen in the Festucetum, which has only been suppressed through a biogenic transformation of the locality.

Just as on the fresh, acid soils Festucetum is formed, on the sunny, limestone slopes the Seslerieto-Semperviretum invariably makes its appearance, even when a Festucetum seeds mixture is sown down and manure is applied. Only in old swards can manuring alter the balance in favour of the Festucetum if there is an abundance of *Festuca rubra commutata* (and *Phleum Michelii*) in the sward.

DANISH EXPERIMENTS WITH SEEDS MIXTURES.*

[Reviewer: R. Peter Jones.]

Experiments with different seeds mixtures were carried out under the direction of the Seeds-mixture Committee appointed in December, 1931. The Committee consisted of J. Hansen, the four grassland advisers and the four advisers of the county agricultural societies.

The plans in accordance with which the experiments were set up in 1934 were as follows:

Plan 1. Experiments in which varying amounts of seed of grasses were added to the same legume mixture.

Plan 2. Experiments with early and late red clover.

Plan 3. Experiments with red clover and white clover.

Plan 4. Experiments with varying amounts of seed of legumes.

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Plan 1. Experiments in which varying amounts of seed of grasses were added to the same legume mixture:

(a) Legumes + 3 perennial ryegrass, 1.5 meadow fescue, 1 timothy.
(*b*) do. + 6 do. 3.0 do. 2 do.
(*c*) do. + 9 do. 4.5 do. 3 do.

The legume mixture sown consisted of 10 kg. Øtofte medium-late clover + 2 kg. Morsø white clover.

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Plan 2. Experiments with early and late red clover:

(*a*) 12 Øtofte early clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.
(*b*) 12 Øtofte medium-late clover, 6 do. 3 do. 2 do.
(*c*) 6 Øtofte early clover and
6 Øtofte medium-late clover, 6 do. 3 do. 2 do.

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Plan 3. Experiments with red clover and white clover:

(*a*) 0 Øtofte medium-late clover, 6 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.
(*b*) 8 Øtofte medium-late clover, 4 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.
(*c*) 12 Øtofte medium-late clover, 0 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

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*Rasmussen, L. Foreløbig Meddelelse om Forsøg med forskellige Frøblandinger. Beretning om Virksomheden i Foreningen af jydske Landboforeningers Graesmarkssektion. 1936. pp. 19-25. Skanderborg, 1937. [Preliminary report on experiments with different seeds mixtures. Report on the work of the Grassland Section of the Union of Agricultural Societies of Jutland. 1936. pp. 19-25. Skanderborg, 1937]

(*d*) 8 Øtofte early clover, 4 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

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Plan 4. Experiments with varying amounts of seed of legumes :

(*a*) 8 Øtofte medium-late clover, 3 timothy.
(*b*) 12 do. 3 do.
(*c*) 8 Øtofte early clover, 3 perennial ryegrass, 3 Italian ryegrass.
(*d*) 12 do. 3 do. 3 do.

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Seed of the following strains of grasses was sown : perennial ryegrass E.F. 79 ; meadow fescue, Øtofte ; timothy, Lyngby, and Italian ryegrass, Roskilde. In the experiments conducted according to Plan 4, Øtofte ryegrass was used and not E.F.79. The figures in the plans show the rate of seeding in kg. per ha.

All the experiments with the exception of those referred to in Plan 4 were set up as duplicate experiments. The crop in the one experiment was designed to be cut three times in the course of the summer, so that utilization would correspond to an early hay cut with two subsequent grazings, and in the other experiment it was planned to take 5 cuts during the growing period corresponding to grazing. The experiments set up according to Plan 4 were sown as single experiments, and only 2 cuts were taken during the first harvest year. All the single experiments were put down with 6 joint plots of 25 sq. metres.

From the crop from each cut and each treatment two samples of the green mass were taken immediately after cutting. One of these samples was analysed to determine the content of legumes, grasses and weeds. The other sample was sent to the State Plant Breeding Laboratory, where the content of dry matter of the green crop was determined.

In the spring of 1934, twenty experiments were set up in accordance with each of the four plans. The seed was sown broadcast in a nurse crop and lightly harrowed and rolled.

In 1932, experiments were put down in accordance with similar plans. The results of these and also the results from the first harvest year of the experiments put down in 1934 have been included in a preliminary communication in the Plant Breeding Reports for 1933, 1934 and 1935.

From the experiments laid down in 1934 results are available for the second harvest year from 13 experiments according to Plan 1, 12 experiments according to Plan 2, and 12 experiments according to Plan 3. Owing to the severe and protracted drought in the seeding year the delicate young plants in many parts of the country died out completely or partially, with the result that many of the fields on which the experiments had been put down were either ploughed up or re-sown. The experiments were abandoned before harvesting. As a result of the dry period in the summer of 1936 some of the experiments were not carried out exactly according to plan, as the crops, owing to low rainfall, ceased growth, so that the intended number of cuts could not be taken. The experiments in 1936 were carried out with the following number of cuts.

kg. seed sown per ha.								Few cuts					Many cuts						
								hkg. per ha.					hkg. per ha.						
Øtofte medium-late clover.	Øtofte early clover	White clover	Total clover seed	Perennial rye-grass	Meadow fescue	Timothy	Total grass seed	1st cut	2nd cut	3rd cut	Total	Per cent legumes	1st cut	2nd cut	3rd cut	4th cut	5th cut.	Total	Per cent legumes.
Plan I. (Average of 13 trials)								Green mass							Green mass				
10	,,	2	12	3	1.5	1	5.5	221	82	13	316	44	96	74	59	37	4	270	44
10	,,	2	12	6	3.0	2	11.0	221	84	13	318	44	98	73	59	36	5	271	45
10	,,	2	12	9	4.5	3	16.5	222	84	14	320	44	98	73	58	35	5	269	44
								Dry matter							Dry matter				
10	,,	2	12	3	1.5	1	5.5	48.9	19.9	3.7	72.5	,,	18.3	16.6	12.1	8.1	1.1	56.2	,,
10	,,	2	12	6	3.0	2	11.0	48.2	19.7	3.8	71.7	,,	18.7	16.3	12.1	8.0	1.1	56.2	,,
10	,,	2	12	9	4.5	3	16.5	49.5	20.4	3.9	73.8	,,	18.5	16.5	12.1	7.9	1.1	56.1	,,
Plan 2. (Average of 12 trials).								Green mass							Green mass				
,,	12	,,	12	6	3	2	11	158	69	9	236	38	66	72	54	21	5	218	39
12	,,	,,	12	6	3	2	11	189	83	12	284	47	83	87	70	29	6	275	48
6	6	,,	12	6	3	2	11	172	77	10	259	43	74	80	64	25	5	248	44
								Dry matter							Dry matter				
,,	12	,,	12	6	3	2	11	42.4	17.8	3.0	63.2	,,	15.0	17.8	11.6	5.0	1.3	50.7	,,
12	,,	,,	12	6	3	2	11	46.5	20.0	3.5	70.0	,,	16.8	19.1	14.0	6.6	1.5	58.0	,,
6	6	,,	12	6	3	2	11	45.5	18.9	3.1	67.5	,,	16.0	18.9	13.1	5.9	1.3	55.2	,,
Plan 3. (Average of 12 trials)								Green mass							Green mass				
0	,,	6	6	6	3	2	11	146	47	11	204	27	73	75	34	27	5	214	35
8	,,	4	12	6	3	2	11	196	74	16	286	52	82	89	50	41	7	269	49
12	,,	0	12	6	3	2	11	205	83	17	305	55	82	91	55	45	7	280	53
0	8	4	12	6	3	2	11	168	67	14	249	43	73	76	40	34	6	229	41
								Dry matter							Dry matter				
0	,,	6	6	6	3	2	11	44.1	10.7	3.3	58.1	,,	15.2	16.5	8.1	6.5	1.3	47.6	,,
8	,,	4	12	6	3	2	11	54.2	15.5	4.6	74.3	,,	16.4	18.8	11.1	9.1	1.7	57.1	,,
12	,,	0	12	6	3	2	11	54.3	16.2	4.8	75.3	,,	16.2	18.8	11.8	9.7	1.9	58.4	,,
0	8	4	12	6	3	2	11	49.8	14.4	4.4	68.6	,,	15.0	16.7	9.3	7.7	1.6	50.3	,,

	Few cuts.			Many cuts.				
	1 cut	2 cuts	3 cuts	1 cut	2 cuts	3 cuts	4 cuts	5 cuts
Plan 1. No. of experiments	13	13	5	13	13	13	10	3
Plan 2. do.	12	12	6	12	12	12	9	3
Plan 3. do.	12	12	7	12	12	12	10	4

In this preliminary report only the average yield of green mass and dry matter for each individual cut and also the total yield of all the cuts are cited. In the calculation of the average yield for the individual cuts, the yield figures from the individual experiments are added together and divided by the total number of experiments for the experimental group in question irrespective of whether the full number of cuts was taken in all the experiments. With this method the average yield from the individual cuts added together gives the total yield for the experimental group concerned.

From the results of experiments with varying rates of seeding of grass seed it is seen that in the experiments conducted from 1932 to 1936 the following relative yields were obtained from the various seeds mixtures :

	Few cuts			Many cuts		
	1st year	2nd year	Total.	1st year	2nd year	Total.
Number of trials.	29	25	„	29	25	„
	Green mass			Green mass		
Legumes + 5.5 kg. grass seed ..	100	100	100	100	100	100
Do. + 11.0 kg. do.	100	101	100	99	100	100
Do. + 16.5 kg. do.	99	102	100	98	100	99
	Dry matter			Dry matter		
Legumes + 5.5 kg. grass seed ..	100	100	100	100	100	100
Do. + 11.0 kg. do.	100	100	100	100	100	100
Do. + 16.5 kg. do.	102	102	102	99	100	99

According to these preliminary results there does not appear to be any particular reason for using the large amounts of grass seed in the seeds mixture as the yields obtained have been almost identical after the three different amounts of grass seed included. It should, however, be borne in mind that some of the experiments were abandoned owing to a sparse plant stand on the experimental area ; in those instances as a rule the lack of legumes was most striking. On soils, therefore, where legumes for some reason or other do not thrive, the reduction in the amount of grass seed in the seeds mixture should not proceed too far. Of the amounts of grass seed tested the intermediate one will as a rule be suitable.

In the experiments conducted according to Plan 2 during the years 1935-36, on the average the following relative yields were obtained :

Øtofte early clover gave in the first harvest year approximately ten per cent and in the second harvest year approximately twenty per cent less green mass than Øtofte medium-late clover. The yield of dry matter of early clover was in the first harvest year from three to nine per cent and in the second harvest year from ten to thirteen per cent lower than that of medium-late clover. The content of legumes in the green crop was in the first harvest year three per cent and in the second harvest year nine per cent greater where medium-late clover had been sown than where

	Few cuts			Many cuts		
Number of experiments.	1st year 13	2nd year 12	Together ,,	1st year 13	2nd year 12	Together ,,
	Green mass			Green mass		
Grass mixture + Øtofte medium-late clover	100	100	100	100	100	100
Do. + ½ medium-late and ½ early clover	96	91	94	95	90	93
Do. + Øtofte early clover	92	83	87	89	79	84
	Dry matter			Dry matter		
Do. + Øtofte medium-late clover	100	100	100	100	100	100
Do. + ½ medium-late and ½ early clover	100	96	98	97	95	96
Do. + Øtofte early clover	97	90	94	91	87	90

early clover had been used. On the plots where the seed sown consisted of half medium-late and half early clover the harvested yields in size and quality lay approximately midway between the yields on the plots where the seeds mixtures contained medium-late alone or early clover alone.

If the total yield of green mass for all the cuts be placed at 100, the yield in the individual cuts is distributed as follows :—

	Few cuts				Many cuts					
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Fourth cut	Fifth cut	Total
	1st harvest year				1st harvest year					
Grass mixture + medium-late clover ..	78	14	8	100	24	39	20	10	7	100
Do. + ½ medium-late and ½ early clover	75	16	9	100	24	37	20	11	8	100
Do. + early clover	73	18	9	100	25	37	19	11	8	100
	2nd harvest year				2nd harvest year					
Grass mixture + medium-late clover ..	67	29	4	100	30	32	25	11	2	100
Do. + ½ medium-late and ½ early clover	66	30	4	100	30	32	26	10	2	100
Do. + early clover	67	29	4	100	30	33	25	10	2	100

The aftergrowth of the two strains of clover would thus appear to be almost identical, when many cuts are taken. If a comparatively late first cut be taken, as was the case where the cuts were few, medium-late clover in the subsequent cut yields slightly less than early clover, but after an early cut the aftermath appears to be the same in the two strains of clover.

In the experiments conducted according to Plan 3 with the same grass seed mixture a comparison was undertaken between the yields of seeds mixtures in which red clover and white clover were included in varying amounts. The following relative yields were obtained from the different mixtures.

	Few cuts			Many cuts		
	1st year	2nd year	Total	1st year	2nd year	Total
Number of experiments.	21	18	„	21	18	„
	Green mass			Green mass		
Grass mixture + 12 Øtofte medium-late clover, 0 white clover. ..	100	100	100	100	100	100
do. + 8 do. 4 do.	95	95	95	99	97	98
do. + 0 do. 6 do.	78	69	74	84	76	80
	Dry matter			Dry matter		
do. + 12 do. 0 do.	100	100	100	100	100	100
do. + 8 do. 4 do.	96	98	97	99	97	98
do. + 0 do. 6 do.	84	79	82	86	81	84

On the average of the first and second harvest years the seeds mixture which contained only white clover and grasses has yielded 20 to 26 per cent less green mass, corresponding to 16 to 18 per cent less dry matter, than the seeds mixture which contained only medium-late clover and grasses. The mixture with 8 red clover and 4 white clover in addition to grasses has given considerably more than when white clover was the only legume included, but the yield of both green mass and dry matter was slightly lower than when only red clover and grasses had been sown. It should be pointed out that all the experiments were carried out on arable. On meadows and fen-land the conditions will possibly be more favourable for white clover.

The yield of green mass by red clover and white clover is apportioned as follows for the individual cuts, the total yield of all cuts being placed at 100 :

	Few cuts				Many cuts					
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Fourth cut	Fifth cut	Total
	1st harvest year 1935				1st harvest year 1935					
Grass mixture + 12 medium-late clover, 0 white clover.	77	17	6	100	21	41	21	12	5	100
Do. + 8 medium-late clover, 4 white clover.	77	17	6	100	22	41	22	10	5	100
do. + 0 medium-late clover, 6 white clover.	81	15	4	100	24	42	24	6	4	100
do. + 8 early clover, 4 white clover. ..	75	19	6	100	23	39	23	10	5	100
	2nd harvest year 1936				2nd harvest year 1936					
Do. + 12 medium-late clover, 0 white clover.	67	27	6	100	29	32	20	16	3	100
Do. + 8 do. 4 do.	69	26	5	100	30	33	19	15	3	100
Do. + 0. do. 6 do.	72	23	5	100	34	35	16	13	2	100
Do. + 8 early clover, 4 do.	67	27	6	100	32	33	17	15	3	100

In the first part of the growing period white clover has yielded from two-thirds to three-fourths of its whole production. In the last part of the period—second and third cuts for " few cuts " and third, fourth and fifth cuts for " many cuts "—the aftergrowth of white clover, probably as a result of low rainfall, failed in part. The yield of red clover was more uniformly distributed over the whole growing period than the yield of white clover. Corresponding results can be deduced from the experiments which were carried out in the years 1933 and 1934.

In the experiments conducted according to Plan 4, a comparison was instituted between varying amounts of clover seed in the same grass seeds mixture. The experiments were carried out partly with Øtofte medium-late clover and partly with Øtofte early clover. The following relative yields were obtained from the different seeds mixtures :

		Green mass	Dry matter
		Average of 25 experiments	
12	Øtofte medium-late clover + 3 timothy.	100	100
8	do. + 3 do.	97	97
		Average of 9 experiments	
12	Øtofte early clover + 6 ryegrass	100	100
8	do. + 6 do.	97	97

Reduction of the amount of red clover seed in the seeds mixture from 12 to 8 kg. per hectare has caused a decrease of 3 per cent in the yield of both green mass and dry matter.

LUCERNE IN THE SOVIET UNION.*

THE present area under lucerne in the Soviet Union exceeds 800,000 ha., but this is inadequate to meet the demand for this crop, and considering its importance in fodder production. In the past, lucerne cultivation was to a great extent restricted by a deficiency of varietal seeds, but this has now been overcome as the reserves of elite stock are maintained, although in varying quantities, at a number of breeding centres.

In the first place should be mentioned the Central Plant Breeding Station of Śred.Az. N.I.H.I., Tashkent, where " under the direction of A.I. Belov breeding work is arranged in an exemplary manner " ; there are not only good lines of Khivian lucerne, but also some superior selections from lucernes of Ferghana, Parken and Semiryechensk. In addition, successful selections have been made from Arabian lucerne for the southern regions of Central Asia and from lucernes of Asia Minor and Europe, which are suitable for dry farming in that country.

The Siberian Institute of Grain Husbandry, Omsk, has elite stock of its own Western Siberian *falcata-sativa* lucernes, such as No. 8893 (Grimm Omskiĭ) recom-

*Adapted from the Report delivered by E. N. Sinskaja at the February Session of the USSR Academy of Agricultural Science held in 1936, and published in *Trudy Prikl. Bot., Genet. i. Selekcii*, Ser. A. No. 20. 1936. 5-19.

mended for the northern and eastern Trans-Ural steppes with an annual rainfall of over 350 mm., a drought resistant " Pestraja " (variegated) No. 1661 and yellow Omsk lucerne No. 2551, derived from the indigenous wild lucerne ; the last-named is quite reliable in winter hardiness, while its drought resistance makes it suitable for arid steppes with an annual rainfall of about 200 mm. Finally, there is a very interesting tall lucerne of the *sativa-falcata* type known as Bulatovskaja. The Omsk lucernes, which are built up under extreme climatic conditions, may indeed be of use outside Siberia.

The Experimental Station at Kamalinsk is breeding a hybrid *falcata* lucerne ; as this type is very interesting and there is no other variety to suit that peculiar district, it is recommended for immediate reproduction for temporary local use, even before the final stages of its breeding and the State varietal test.

The Experimental Stations at Krasnyï Kut and Kinel have some hybrid lucernes which have stood the test in many places, but seeds of these lucernes are not yet available in large quantities. At the Kemennostepnaja Station, Voronezh region, there is a selection from Asia Minor lucerne ; although intended for good cultivated soils, this lucerne may be used on poor soils until hardier varieties are available.

The Experimental Station, Kazan, has its own hybrid lucerne which has yielded more than others tested at the Station ; elite stock of this lucerne may also be recommended for immediate reproduction for local use.

Comprehensive work has been carried on in Ukraine, where an excellent elite strain of blue Ukrainian lucernes and Grimm Zaïkevič, a hybrid lucerne, is available at various breeding centres. The Ukrainian lucerne, the merits of which were described by V. M. Rabinovič (*Herb. Abstr.* 7. 18. 1937) may also be grown outside Ukraine ; particular attention should be given to the production of seed.

The Klara Zitkin Station (formerly " Marusino ") has its own yellow lucerne No. 425 and a hybrid lucerne No. 31 ; as these can endure flooding for considerable periods they are of particular value for periodically flooded lands where legumes do not succeed. Shatilovo lucerne is also suitable for growing on the northern limits of lucerne cultivation.

In the southern parts of Armenia and Azerbaijan an indigenous type of Armenian lucerne has occasionally been preserved, represented by two ecotypes, upland and highland. The latter is linked through intermediate forms with local wild lucerne and is suitable chiefly for use on local grasslands. The upland ecotype possesses some valuable characters, such as vigorous tillering, leafiness, and resistance to adverse conditions and diseases. In root morphology this lucerne resembles the yellow lucerne and has a similarly favourable effect on soil structure. Armenian lucernes show a remarkable longevity, certain areas having been used continuously for 50 years or more without reseeding. The value of this lucerne in that country is very high, while for breeding purposes it is of importance in places far from Transcaucasia, as certain characters such as number of tillers, softness of stem and large number of fine roots have their maximum expression in these ecotypes of blue

lucernes. Armenian lucerne behaved differently according to the place of test ; in northern Caucasus (Otrada Kubanskaja) it seeded poorly but retained all its other valuable properties, while in Omsk it seeded excellently. The preservation and reproduction of these lucernes deserve more care.

At the Maikop Station there is elite stock of selections from lucernes of Asia Minor, suitable for uplands with adequate moisture. Finally, at the Kuban Station there is a hybrid *falcata-sativa* variety (Ladak) and a yellow lucerne selected from a wild indigenous ecotype which give a large seed yield (up to 6 kg. per ha.).

In northern Caucasus occur some forms of yellow lucerne of which the upland ecotype is outstanding. The successes achieved in work with upland ecotypes suggest the advisability of the reproduction and use of indigenous forms until the deficiency in elite seed is overcome. Wild lucernes must not, however, be recommended for practical use without a thorough test under farming conditions, but at the present time some forms and the region in which they retain their properties are more or less well known. Thus in the environs of Omsk indigenous yellow lucerne is very drought resistant and yielded more than all other types tested there. The Omsk yellow lucerne differs only in its erect habit. In the non-black soil belt the northern Mologa-Sheksna or Ivanovo lucerne is well known ; this hardy ecotype succeeds under mowing or grazing conditions and is promising outside its own region.

Medicago coerulea is being studied in improvement work at the USSR. Institute of Fodders in the Moscow region ; it has good roots, a satisfactory yield and is more salt and drought resistant than any ecotype of yellow lucerne. It is promising for cultivation in semi-deserts. The same Institute now recommends a wild form of yellow lucerne from Orsk. Some other valuable types of wild lucerne have been discovered, for example, the Altai group or the Ukrainian yellow lucerne from Provalie, but their agricultural value is still to be ascertained.

Agrostologists frequently complain of the lack of suitable hay and pasture plants and suggest the formation of a special pasture red clover, while yellow lucerne is already at their disposal. Yellow lucerne has greater longevity, endures grazing, is very hardy, resistant to drought, flooding and fungous diseases, thrives in mixtures and restores the soil structure by its very branching root system. Found in the arid south, as well as in the rigorous conditions of the north, yellow lucerne is suitable as a hay-pasture crop practically everywhere in the Union. Until special pasture varieties are introduced the improvement of grassland must be based upon yellow lucerne and its wild ecotypes, provided that a proper ecotype is chosen, if the indigenous types are not considered to be quite reliable.

The collection of seed must be organized on a larger scale and seed production must be speeded up ; at the same time yellow lucerne must be tested on various types of grassland and in various mixtures. The seed supplies for this work are still deficient. Varietal resources are, however, available from various Stations, and regions can thus be supplied with suitable elite stock ; natural stands may be used to supplement these stocks.

The Seed Varietal Testing Service is still undergoing organization and has not

yet acquired adequate information for the regional distribution of varieties; as far as fodder plants are concerned, only the regional distribution of plants can be outlined. For economic reasons the reproduction of elite stock for practical use cannot be postponed until more information is available and consequently the regional reproduction of seed and the regional distribution of varieties must be temporarily based upon the incomplete, but quite reliable, information which is available as a result of varietal tests at various Stations.

Seed production must be speeded up, particularly at those stations which possess valuable elite stocks. The technique of seed production must be revised in harmony with the biology of lucerne; disregard of the biological properties has made it impossible to obtain a good seed yield in the first year, while in some regions, for example, northern Caucasus, lucerne plants flower in the first year at a more favourable season than in the subsequent years and can thus produce a greater seed yield in the first year. Thick broadcast sowings must be abandoned; at the first phases of reproduction, seeds should be sown in pockets, ensuring a high coefficient of reproduction. Later reproductions on a commercial scale may be made with broad drills.

To ensure a higher forage yield the technique of cultivation also requires revision as there is experimental evidence to show that the real cause of the decrease in the third year is the discrepancy between the type of sowing used and the biology of the crop. A study of phasic development offers new possibilities in increasing the seed and forage yield, particularly in the first year.

The question of seed-growing centres is also important. As seed production in northern Caucasus is still in the process of organization, the Khorezm oasis is practically the only seed growing centre in the Union. Seed growing must be extended in the Ukraine and south-west Russia (in the environs of Krasnyĭ Kut and Kinel) and commenced in south Caucasus. There is experimental evidence to show that blue and yellow forms give an excellent seed yield in the Omsk district. As lucerne from this area succeeds far beyond the Omsk district, it can be regarded as suitable for seed production mainly of *falcata* lucernes for use in other parts of the Union.

Apart from the speeding up of seed production the breeding of new varieties must be promoted. In the present work with yellow lucerne one has to proceed from wild forms, the study of which has disclosed a large number of climatypes containing various ecotypes and forms. The following chief types of yellow lucerne could be recognized.

Types of Yellow Lucerne.

(1) *Northern type* from the non-black soil zone, which possesses some valuable characters, such as vigorous tillering, soft stems and leaves, good leafiness, resistance to grazing and cold, and earliness. The seed yield is good in the native region, but is better in Omsk. A lower resistance to drought than any other type is a defect. The type is valuable for pasture use and for hybridization with blue lucernes, as some characters are most fully expressed in it.

(2) *Ukrainian steppe type*, particularly the ecotype from Provalie, grows well and rapidly after cutting; it gives a high yield in the European part of the Union,

but fails in western Siberia. Its defects include small leaves and a rather low seed yield. This type is valuable on grasslands in Ukraine and for hybridization with blue lucerne, in order to obtain hybrids suitable for Ukraine and the non-black soil region.

(3) *Northern Caucasian steppe type* is very similar to the previous type. It also fails in western Siberia, but is very valuable for cultivation in the steppes of northern Caucasus. It contains a large number of forms which still require to be studied.

(4) *Upland type* from the western part of northern Caucasus is very tall, produces a large forage and seed yield and is very winter hardy, but its leafiness is rather inadequate, although compensated by the softness of leaves. This lucerne is valuable for cultivation and hybridization.

(5) *Azov sandy type* is an erect plant, but has coarse stems. It is of interest for the reclamation of the sandy lands of southern rivers.

(6) *Orenburg rhizomatous type.* Owing to a deeply situated tillering node this type must be very resistant to frost and grazing. The rhizomatous forms are erect; they are reproduced in Omsk.

(7) *The west Siberian type* is hardy, and produces a good yield of seed and somewhat coarse forage. It should be tested for pasture use both within and outside Siberia and also for hybridization with blue lucernes.

(8) *Altai group of types.* The Altai is the secondary centre of origin of yellow lucerne. Many forms produce a high forage yield, are leafy, have tender stems and are exceptionally winter hardy, but the seed yield is not stable. (low yield in north Caucasus, higher in Omsk). The great diversity of forms suggests that selection will be very effective; this interesting group has not yet been fully studied.

(9) *South Kazakstan steppe type* is resistant to drought and heat; its drawbacks are low winter hardiness, poor leafiness and small leaves. It is quite unsuitable for western Siberia, but gave good results in Lori (moist uplands of Armenia); it is valuable for arid zones.

The various types of yellow lucerne behave differently according to the place of test. In yield of forage and hay the imported types are frequently better than the native, but in seed yield the indigenous types or those from neighbouring regions are usually superior to the imported. Some types produce a more stable seed yield than others.

All the types of yellow lucerne are very polymorphous. While retaining the main characters of the type, they vary widely within populations and show considerable differences between the populations belonging to the same type. This facilitates the improvement of ecotypical selections by subsequent mass and group selection.

In breeding blue lucerne the wild gene representation is of minor importance. With the exception of *Medicago coerulea*, which is regarded as a sub-species of *M. sativa*, wild Caucasian forms are of value only as pasture plants and chiefly in their own country. Blue lucerne, however, is the most ancient fodder crop and under

cultivation numerous and diverse ecologo-geographical types have been formed in various parts of the extensive area over which it has been cultivated. Hitherto it has been chiefly the Central Asian and West European lucernes, the American hybrids and to a lesser extent Arabian lucerne (including forms from Chile and Peru) and lucernes from Asia Minor which have been employed in breeding, the remaining rich gene material being left unused. The entire collection of cultivated forms must now be introduced into breeding work. The classification of blue lucerne was initiated by Belov (Herbage Publication Series Bulletin No. 6 and *Herb. Abstr.* 7. 209. 1937) and Bordakov (*Herb. Abstr.* 6. 44. 1936) and recently revised by Lubenec (*Herb. Abstr.* 7. 210. 1937).

In breeding schemes there are two items which have frequently been overlooked. The first is concerned with rhizomatous forms. These forms were found in Poltava, Karaganda, Maikop, Omsk and elsewhere, but their value for pastures is not yet known.

The other item is concerned with the effect of lucerne on soil structure. The idea that blue lucerne is unable to restore the soil structure and that preference should be given to yellow lucerne is too general to be correct. The type of root system varies with the type of lucerne and, if Turkestan lucerne has a few thick roots, there is, on the other hand, a lucerne from Asia Minor which has abundant fine lateral roots capable of restoring soil structure. Cultivated and wild forms from Armenia are of exceptional value in this respect (*Herb. Abstr.* 7. 19. 1937); their root system consists of many soft roots and a stunted or frequently absent tap root and resembles that of the yellow lucerne. The explanation lies in the common origin (syngameon) of blue and yellow lucernes; in Transcaucasia, the centre of their common origin, the characters of these species have not yet been fully differentiated. It is possible to find, therefore, forms of blue lucerne which can have just as favourable an effect on the soil structure as yellow lucerne. This aspect must not escape attention in the choice of basic plants.

Methods of Breeding.

As to the methods of breeding, the following phases can at present be outlined:

(1) reproduction of the existing varietal elite stock for use in the near future;
(2) improvement of existing varieties and hitherto unused ecologo-geographical types through selection by groups and other methods of analytical breeding;
(3) breeding of very valuable hybrids.

The great variety of populations in many types would suggest that selection by types and groups within populations of the same origin may be very effective. The groups should be chosen not only in respect of characters determining fodder value, but also for characters of an ecological nature, such as a prostrate rosette, which usually suggests lateness and winter hardiness. Selection by types and groups is likely to be more practicable than individual selection in dealing with the diverse populations of existing hybrid varieties; on the whole, at present " selection by

types and groups appears as the basic analytical method of breeding fodder plants " in general.

In work with lucerne the method of inbreeding has also been used. This requires an adequate knowledge of the biology of pollination, which has been studied at two north Caucasian stations of the Institute of Plant Industry. In the environs of Maikop (moist uplands), lucerne is pollinated chiefly by insects, while in Otrada Kubanskaja (a dry steppe), during the first half of summer, lucerne is mostly self-pollinating. The character of the pollination also depends to a great extent upon the surrounding vegetation ; in Lori, Armenia, for instance, lucerne plants are not visited by the honey bee when growing in association with sainfoin. It is quite possible that in any region a period during the summer can be established when conditions are most favourable for self-pollination and there is the least danger of cross-pollination. This finding may make it unnecessary to use mass isolation in individual selection. The biology of lucerne pollination requires to be studied further in this respect.

As lucerne under natural conditions shows a tendency to self-pollination, inbreeding is not actually an enforced selfing ; consequently no profound change nor any serious depreciation in vigour can be expected as a result of inbreeding. This method can then be used for preserving and maintaining previous selections and not for obtaining something new and markedly different from the initial plant. No-one has yet succeeded through inbreeding in going beyond the limits of an ecotype. Belov inbred the Khivian lucerne repeatedly, but always obtained forms of the Khivian type ; the same result was obtained by Sinskaja in the inbreeding of lucerne from Asia Minor. Inbreeding should thus be used after ecotypical selection. Some of the lines inbred by Belov, however, give much higher yields than the initial plants, thus showing that through inbreeding the extreme expression of a character within the variation range adherent to the ecotype can sometimes be fixed or the range may even be extended. In the face of this experimental evidence, inbreeding cannot be discarded, but it must be employed cautiously, as a population may accidentally contain some plants of higher agricultural value, but which have no rudiments of that stability which is typical of the ecotype selected. In all cases attention must be directed to the range of main ecotypical characters and an inbred line must be compared with the initial population and not with the initial (basic) plants.

The range of possibilities offered by the analytical methods are, however, limited and it would be impossible by these means alone to make full use of the entire eco-geographical potentialities of blue lucerne ; this can be attained only through hybridization.

A rapid increase in the area under hybrid lucernes in all parts of the world suggests that in future the extension of lucerne cultivation beyond the limits of the present area will be effected at the expense of hybrid varieties.

The cause of interspecific hybridization, as well as the success hitherto attained and the unchallenged superiority of the hybrids, lies in the phylogenesis of the parent species. Investigations have shown (*Herb. Abstr.* 7. 208. 1937, and *Herb. Rev.*

5. 202-4. 1937) that *sativa* and *falcata* lucernes sprang from the same syngameon in Transcaucasia. Genetically, therefore, these two species are as close as subspecies of the same species and can, therefore, cross readily. Descending from the same complex of forms which cover the characters of both species, in later migrations they became differentiated, the *sativa* lucerne mainly in the west and south-west and *falcata* lucerne in the north and east. When crossed they restored the initial, but now somewhat changed and enriched form which thus acquired a greater universality ; hence the superiority of the hybrids.

With the exception of forms obtained by P. N. Konstantinov, the hybrid varieties cultivated in the Union have arisen as a result of natural hybridization. Some natural hybrid populations moulded by natural selection into more or less uniform types were found in various parts of the Union, but hitherto resources of wild hybrid forms have been little used. Plant breeding, however, must not be restricted to the use of natural hybrids. There does not exist, for instance, a hybrid with the soft stemmed Maikop upland type, nor is there a hybrid between the northern type of yellow lucerne and blue lucerne, as their areas are not contiguous ; meanwhile, the northern (Ivanovo) lucerne is particularly valuable for hybridization as a number of characters are fully expressed, thus suggesting that very fertile hybrids for the north may be obtained. Therefore, artificial hybridization is essential between the best representatives of yellow and blue lucernes.

Apart from this an inter-ecotypical hybridization must be attempted. This trend is quite new, not a single variety in the Union being known to have arisen as a result of crosses between ecologo-geographical types of blue lucerne.

Inter-ecotypical hybridization should be used within the main belt of lucerne cultivation and inter-specific hybridization on the periphery thereof. Whenever conditions permit, hybrids should replace yellow lucerne ; the latter, however, will be retained in arid zones, and elsewhere for use on grasslands.

Hybridization in the U.S.S.R. can then be planned as follows :

(1) Siberian Institute of Grain Husbandry, Omsk, Western Siberia : interspecific hybridization.

(2) Central Plant Breeding Station at Sred.Az.N.I.H.I. : inter-ecotypical hybridization.

(3) Ukrainian Institute of Animal Breeding, Poltava : interspecific and inter-ecotypical hybridization.

(4) USSR Institute of Plant Industry, Leningrad : interspecific and inter-ecotypical hybridization at the Maikop and Otrada Kubanskaja Stations.

Hybridization between lucernes is facilitated by the fact that under the same conditions higher fertility is dominant.

It may be hoped that as a result of collective work new varieties, superior to those now in existence, will be built up and will enable agriculturists to extend the cultivation of this crop far beyond its present limits, southwards to the arid belts and northwards into the rigorous and wet belts.

Lucerne is destined to play an outstanding part in the reclamation of highlands. According to Baranov's report the test of lucernes in the Pamir at an elevation of 3,600 m. has given quite unexpected results. All types, including Arabian lucerne, which winter poorly in the lowlands, wintered there excellently. It was found that under these conditions lucerne accumulates a greater amount of sugars, thereby ensuring better wintering. This experimental evidence suggests how little is known about ordinary crops and their possibilities. The search for new species for introduction into cultivation is indeed very valuable and must be continued, but first it is necessary to make the fullest use of and to improve upon the centuries of experience of mankind with ancient crops. The use of all possible resources and the application of new methods may revive the ancient crops and lead to their re-discovery. Thus lucerne is one of the most ancient fodder crops, and yet at the same time is the crop of the future.

USSR ACADEMY OF SCIENCES

Research at the Institute of Plant Physiology*

THE Institute originated from a small Laboratory of Plant Anatomy and Physiology founded in 1889 by Academician A. S. Famincyn, who was succeeded in 1918 by Academicians I. P. Borodin and V. I. Palladin. After the revolution the Laboratory was practically closed until the end of 1923, when under the directorship of Academician S. P. Kostyčev its research was resumed, attention being devoted almost exclusively to problems of practical importance, such as microbiology and biodynamics of soil, the chemistry of photosynthesis, nitri- and de-nitrification, secretion of citric, lactic and gluconic acids, enzymology and the chemistry of various fermentations. During that period the Laboratory changed its name into the Laboratory of Biochemistry and Plant Physiology. In 1932 Academician A. A. Richter was elected as director and the scope of the work was extended mainly in the fields of plant physiology and the physiological bases of plant breeding and agronomy (agrophysiology). In 1934 the Laboratory was converted into the Institute of Plant Physiology and divided by subjects into five laboratories; the following brief review deals with the various research items and results obtained during the last five years.

1. LABORATORY OF PHYSIOLOGY AND PLANT DEVELOPMENT
(In charge of M. H. Čaĭlahjan)

Since 1932 research has been carried out on vernalization, photoperiodism and stimulation.

(a) *Vernalization.*

As a result of the study of respiration, enzymes and the changes in the colloidal

*Richter, A. A. [Synopsis and perspectives of research at Timirjazev's Institute of Plant Physiology of the Academy of Science in U.S.S.R.] *Izv. Akad. Nauk. SSR. Biolog. ser.* 1937. No. 5. 1667-80. [English summary, 1680.]

and chemical properties of embryonic tissues under vernalization, it was found that, as affected by vernalization, the iso-electric point of albumino-lipoids is shifted towards the acid end (Richter, Pekker and Rancan). Changes in the protoplasm in relation to vernalization were further studied by Filippenko, who found an increased permeability of the protoplasm and greater mobility of the albuminous complex in vernalized plants; the general activity of vernalized plants (photosynthesis and accumulation of dry matter) was also intensified. The chemical composition of nitrogenous compounds was studied by Konovalov, who found that in seeds under vernalization and also in sprouting seeds the content of insoluble proteins is increased and is accompanied by a parallel fall in soluble proteins; the content of amino, amide and ammonium nitrogen was higher in seeds or plants under vernalization. Vernalization of embryos with and without endosperm (Konovalov) showed that the processes of vernalization may occur in an embryo without the endosperm. The effect of mineral nutrition on the developmental phases during vernalization has been studied by Abolina. Finally, the comparative study of winter and spring forms (Čaĭlahjan) showed that, as regards some physiological properties (photoperiodic response and chlorophyll formation), there is a series of intermediate plants linking winter and spring forms into a single continuous series.

(b) *Photoperiodism.*

Attention has been chiefly devoted since 1932 to the study of the mechanism of the photoperiodic response of plants; at present the following conclusions were warranted (Čaĭlahjan).

Before the appearance of the first leaf the growing seeds are unable to respond to photoperiods. The factors exerting an effect or speeding up the sexual processes (reproduction) are strictly localized in their action. The sexual processes influenced by light occur in the leaves, and the formative processes occurring in the promeristem are secondary changes controlled by the functions of the leaves.

The developmental processes occurring in plant tissues progress independently of the rate of growth, carbohydrate accumulation and concentration of auxin, and are related to the formation of flower hormones (floregin) in the leaves and the movement of this hormone to the promeristem. This hormone is transferred in the cortex along the stem upwards, downwards and horizontally, and is regulated by the interaction between the leaves and the growing point. No polarity in this movement was observed. On transplantation, the floregin is transferred from the stock into the scion, both as a result of the direct action of the photoperiods upon the former after grafting and its accumulation there before grafting. The floregin is not specific for species or biological forms. No substance inhibiting or retarding flowering is formed in the leaves.

The secretion of floregin does not yet determine the onset of the reproductive processes; for this its accumulation in the leaves and transference into the growing point are necessary. This hormone is indispensable not only for the inception of floral organs, but also for the further processes, including seed setting. It is thus a

sexual hormone. In bi-sexual flowers it influences the inception and functions of the male and female organs ; in unisexual florets the inception of male organs depends upon the male hormone and that of female organs upon the female hormone.

These concepts of the hormonal nature of sexual reproduction of plants are the basis of further research devoted mainly to the processes of sexual development and transplantation of plants (Čaĭlahjan, Ždanova, Jarkovaja and Azbukin) as well as their practical application.

(c) *Stimulation.*

As a result of investigations of the artificial ripening of fruit carried out since 1933, methods of artificial ripening of sub-tropical fruits and vegetables were elaborated and are now used in practice. The study of biochemical processes showed that the accumulation of end products in artificial ripening progressed in the same direction as in natural ripening, but that the rate of these processes is speeded up.

Various methods of breaking dormancy in newly harvested potato tubers were investigated ; sulphuric ether proved to be more effective than other gases, giving the highest percentage of sprouting tubers.

Induced root formation has been studied since 1935. Some gases (carbon monoxide and ethylene) had a favourable effect upon the rooting of some herbaceous plants, but an unfavourable effect on some perennials (*Citrus*). Dipping cuttings in heterohormone solutions, however, speeded up the rooting of perennial plants.

2. Laboratory of Plant Immunity
(In charge of K. T. Suhorukov)

In the study of immunity and the characters of resistance to infectious diseases particular attention has been given to the causes of rotting of fruits and vegetables. This has been found to be due to semi-parasitic polyphagous fungi. The latter were found to be a biological indicator of the content of bios in the fruits. The study of resistance in relation to bios content explained the difference in resistance of various varieties of carrot to the white rot, and water melons to black rot (Suhorukov, Kling and Werner). The relation of semi-parasites to bios predetermines their biological relation to other micro-organisms. For instance, *Fusarium* is attacked by other soil fungi which are attracted by the bios-containing spores and mycelia of *Fusarium*.

The study of the toxins of parasitizing fungi showed their nature and isolated action on the plants (Elpidina, Grečušnikov, Ovčarov and Medvedev). With reference to the response of plants to toxins and the parasite itself, a theory of immunity to rust fungi has been elaborated. The toxins of these fungi (chiefly ammonium and urea) enter in the infected plants into the general exchange of substances and thus reduce their noxious accumulation in the parasite. The toxin content was found to vary with temperature and dryness of soil. This theory finds its support in the geographical distribution of rust epiphytes.

Considerable attention was also given to the study of the disease known as "wilt." The causal factors are *Verticillium albo-atrum* and *V. dahliae*, which

enter the roots from the soil and then spread throughout the entire plant body. Resistance to wilt was found to be related to the hardness of the wood of the roots and stems.

3. Laboratory of Plant Photosynthesis
(In charge of A. A. Richter)

In the last 3 to 4 years the research in this Laboratory has mainly been in connexion with the cultivation of sub-tropical plants, chiefly *Citrus*. The energy of photosynthesis was investigated in relation to ecological factors on the Black Sea coast.

With a normal content of CO_2 in the air most of the plants investigated were not found to require direct sunshine, as the maximum photoperiodism occurs under light of 8.5 to 12 thousand lux intensity. In autumn, when the intensity of sunlight is reduced to 15 to 16 thousand luxes, photosynthesis is particularly vigorous, especially just before the fall of leaves in deciduous plants. A fall in temperature does not generally reduce the energy of photosynthesis and seems to be readily compensated by better light conditions.

Particular attention was given to the accuracy in recording photosynthesis; the alkaline absorber of CO_2 constructed at the Laboratory is being used in many other laboratories.

4. Laboratory of Physiology of Lower Plants
(In charge of V. S. Butkevič)

Before the Laboratory was opened in 1935, research was chiefly confined to bacteriosis and the rhizosphere of agricultural plants. At the present time the Laboratory is studying the respiration of moulds and the elaboration and perfection of the existing methods of obtaining citric acid and sodium citrate.

5. Laboratory of Plant Resistance
(In charge of N. S. Petinov)

Since the establishment of this Laboratory in 1932 research has been concerned with irrigation of the Trans-Volga steppes and particularly the agro-physiological study of methods of irrigation and the physiological bases of optimal rate of watering and manurial treatment.

Artificial " rain " was superior in its effect to the ordinary method of irrigation; it increases assimilation and transpiration and intensifies the biochemical processes of exchange of substances. The protein content of grains is consequently increased. When combined with manurial treatment, ordinary irrigation also does not reduce the protein content.

A continuous water supply and adequate nutrition throughout the vegetative period are required to ensure the highest possible yield. The physiological studies of plant functions enable the Laboratory to elaborate a rational system of irrigation and manuring. The application of this system in the exceptionally dry year of 1936 enabled investigators to obtain a grain yield of 40.3 dz. per ha.

CARNEGIE INSTITUTION OF WASHINGTON

Annual Report of the Division of Plant Biology

[Reviewer: A. R. BEDDOWS]

BIOCHEMICAL INVESTIGATIONS

(*a*) *Leaf pigments.*

MANY of the biologically important substances in leaves undergo rapid modification and loss in quantity after the death of the cells, due chiefly to oxidative disorganization accompanying death. Important activities of leaf cells such as photosynthesis are readily impaired by slight injuries or derangement of the finer structure of the cells. If leaves are killed by means which do not usually inactivate enzymes, such as freezing, grinding or treatment with anaesthetics or noxious gases, a rapid oxidation of the yellow pigment takes place in the presence of oxygen. This does not occur if the enzyme is inactivated. There is indication that the carotinoid pigments in leaves may occur in combination with fat and protein and it is in this combined state that these pigments are very sensitive to oxidation.

The carotinoid pigments of etiolated leaves are oxidized very rapidly and almost completely when the leaves are killed with anaesthetics, but those contained in yellow or variegated leaves, in yellow autumn leaves and in the leaves of certain yellow varieties or strains of plants, are not oxidized rapidly when the plants are killed with anaesthetics. This is also true of pigments in roots, fruits and flowers. The differences in reactivity of the carotinoids may be due to the nature of the plastids, or the state of combination of the pigments.

Living leaves contain appreciable quantities of highly fluorescent colourless substances which are adsorbed on magnesium oxide columns. When leaves are killed with anaesthetics in air, non-fluorescent oxidation products are formed. The absorption spectra of leaf chlorophylls extracted from killed leaves differ from those of solutions obtained by the extraction of living leaves with the same organic solvents.

Chloroplasts when in the living condition can reduce solutions of silver nitrate, but cannot do so when killed. This reaction can be used as a test as to whether the chloroplasts are living. Chloroplasts killed in almost complete absence of oxygen can, however, still reduce the silver nitrate, and the reducing agent, which may be extracted with cold water, is still effective.

A new and very sensitive xanthophyll pigment, eschscholtzxanthin, isolated from the petals of the California poppy, *Eschscholtzia californica*, absorbs oxygen from the air much more rapidly than do any of the naturally occurring carotinoid pigments yet isolated.

Red light (wave lengths from 640 $m\mu$ and 600 $m\mu$ to the infra red) caused a rapid increase of the carotins, xanthophylls and chlorophyll pigments in etiolated barley seedlings. It was found that in the narrow spectral region 470 to 550 $m\mu$, the yellow carotinoid pigments absorbed 50 to 90 per cent of the light absorbed by all the pigments.

(*b*) *Absorption of carbon dioxide by the unilluminated leaf.*

Experiments have shown that, as the carbon dioxide which is absorbed by the unilluminated leaf can be recovered quantitatively, the absorption process is therefore completely reversible. This is true of living and killed leaf material. It is apparently the reaction of some purely chemical system. The identification of the substances responsible for absorption of CO_2 is a difficult problem. An important part is played by water, but the entire absorption cannot all be accounted for by the absorptive capacity of water. A comparison of the absorption capacity of etiolated, luteous and albino leaves of the same species has shown that chlorophyll has no demonstrable effect on absorption of CO_2, and the amount absorbed by chlorophyllous leaves was less than that absorbed by non-chlorophyllous varieties.

Measurements of the CO_2 absorbed by leafy saps and by the solid constituents left after expressing the saps have shown that both residues and sap may be involved in the total absorption of CO_2 by the leaf. The alkaline leaves of the sunflower and the more acid leaves of *Sedum praealtum* behaved rather differently; the former absorbed more and the latter less CO_2 than the amount calculated for the water of the sap.

Calcium and magnesium were the chief basic constituents of the solid residues from sunflower leaves. Quantitatively there was more than enough of these elements to account for the absorption of CO_2 by the leaf residues. The evidence available suggests that they play an important role in the first step of the photosynthetic reaction.

(*c*) *Amylolytic activity of leaves.*

Amylase was selected for the study of the effect of environmental conditions on the activity of the leaf, because its action is fairly well understood, and its substrate starch can be fairly accurately determined. Amylolytic activity is thus used as an indicator of enzymatic function. The role of oxygen in the starch dissolution of leaves has been studied by subjecting them to irrespirable gases and mixtures of these with oxygen. Certain leaves, such as those of the sunflower, can be kept under anaerobic conditions for as long as 24 hours without showing any signs of injury. Starch dissolution in living leaves must be taken as evidence of amylase activity. This varies greatly from species to species and even within the same species in leaves of similar age. The hydrogen ion concentration of the medium has a marked effect on the activity of amylase, and the pH value representing maximum amylolytic activity differs with different leaf material. Amylolytic activity is preserved in the leaf for some time after death. After the severance of the leaf from the plant it decreases rapidly and is gradually lost.

Experimental taxonomy

(*a*) *Evolutionary patterns of the Madiinae.*

A taxonomic synopsis of the 85 species of the Madiinae, a sub-tribe of the Compositae, based upon the principles of experimental taxonomy, and embodying the

results of the various lines of work, has been prepared. Some of the evolutionary patterns taken from different groups within Madiinae are given in the report. Transitions have been found between ecotypes and ecospecies. Results of crosses within three different sections of the genus *Hemizonia* indicate that the barriers between species are determined by the compatibility between the interchangeable genes in the chromosomes rather than by the number of chromosomes themselves or by their apparent homology as determined by their ability to conjugate. Differences in chromosome number, however, almost always produce a barrier.

Cytological investigations lead to the discovery of two new species. One with 24 chromosomes apparently arose through amphidiploidy by hybridization between *Madia dissitiflora* with 16 chromosomes and *M. citriodora* with 8. The other is a tetraploid *Layia* (n = 16) formerly interpreted as an autotetraploid *L. hieracioides* (normally n = 8), but hybrids showed that the chromosomes of the tetraploid and diploid were non-homologous. The tetraploid is now suspected of being amphidiploid between *L. hieracioides* and some unknown 8-chromosome species.

A further 61 Madiinae hybrids have been grown, making a total of about 200 successful combinations, four largely interspecific, but many are intraspecific and two intergeneric.

(*b*) *Transplant experiments* (*varied environment investigations*).

This work is being continued, and considerable data and material are now available illustrating racial (ecotypical) differentiation in environments differing in altitude or latitude, and also material from maritime versus those from interior habitats. Several species have developed spring and autumn races adapted for different seasons in the same habitat, for example, California.

Some plant groups meet the requirements for environmental specialization with different ecospecies, others seem to do it equally well by means of ecotypes. The latter are more desirable for investigations on adaptational values that include genetic analysis than the former, because inherent genetic incompatibilities do not complicate the situation ; the forms of *Potentilla glandulosa* Lindl. sens. lat., meet these requirements and considerable information is now being accumulated regarding this species.

Desert Investigations

Exploration of the lesser known areas of the Sonoran desert is being continued and its flora and ecological features studied.

Thermographs are installed at three levels near the Desert Laboratory and continuous temperature records are now available for each level. The temperature inversion known to exist between the Santa Cruz valley floor and the laboratory has now been found to extend to the top of Tumamoc Hill (764 feet above the valley floor and 429 feet above the laboratory).

Investigations on frost damage to native plants show that the damage suffered by several species will prevent them extending their distribution under prevailing climatic conditions.

Soil moisture determinations show that seasonal infiltration does not exceed one foot, and only once in the seven years for which data are available did it rain enough to infiltrate to a depth of four feet.

Soil temperature is of basic importance and is being studied in relation to air temperature and to soil moisture, as well as regards root growth, seed germination and the behaviour of several classes of animals. In June 1937 the surface soil temperature was 40° to 50° F. higher than air temperature and reached the maximum at 165° F. The critical stage in the life history of desert plants occurs between seed maturity and the establishment of a new individual. Seeds of all large perennials, all cacti and most shrubs germinate at soil temperatures between 80° and 95° F., the prevailing range during the summer rainy season; others at temperatures of 60° to 75°F. which obtain during the winter rainy season. The seeds of most woody perennials germinate at the first favourable opportunity, others in the following year and some not until three years have elapsed. The development of shoot and roots in the first year varies greatly. The form of the successive leaves often shows wide differences as the plants mature. A series of drawings is being made as a record for each species.

The osmotic pressure of expressed sap is regarded by some workers to be a measure of the plant's physiological response to its environment. It was found that variations in the environment of individuals of a given form or race are reflected in the freezing point depressions obtained for the respective individuals. The data for different forms of the same species growing in the same habitat indicated that each has a degree of physiological individuality or stability.

Ecology

(*a*) *Adaptation and origin.*

Extensive use is being made of batteries of phytometers for the purpose of measuring single direct factors or factor complexes under which adaptation is occurring. Sunflower phytometers were used in the length-of-day tests at Santa Barbara to measure the conditions that determine time of flowering. Phytometers are also being used to analyse the functional and structural responses to stable dunes (shelter garden) and mobile dunes (ridge garden) along the sea shore, and to compare them with results in the main garden a few miles inland. In general, stem height proved to be the best integrator of growth conditions.

The grass genus *Stipa* has been selected to set the pattern in the synthetic study of the simultaneous evolution of community and species. *Stipa* plays a dominant role in climax association the world over, and is probably also the chief genus in respect of a number of species, sub-species and forms. Originating in the circumpolar region of the northern hemisphere it has been driven southward by climatic shifts; it has crossed the equator at times of high continental emergence and has spread out over Australia, Africa, and South America far into Patagonia.

The regional species of *Stipa* have been grown extensively in the climatic and edaphic transplant gardens at the Alpine Laboratory, and conversions with phylads,

such as *capillata-comata-spartea* and *viridula-robusta-minor*, have been made repeatedly

The extensive collections in the U.S. National Herbarium have been studied in detail with special reference to the original stocks, and their modification as they were dispersed throughout the globe by virtue of climatic compulsion. The major stocks are largely identical for Eurasia and North America, and several of these continue into South America with the evolution of a host of new forms. The African species are for the most part those of Europe or derivatives of them, while the Australian ones, though evidently derived from Asiatic ancestors, reflect a longer break in land connexions. It seems probable that the line of continuous descent that is represented by *capillata* of Eurasia, *comata* of the Great Plains, *pulchra* of California, *leucotricha* and *mucronata* of Texas and Mexico, and *neesiana* of Central and South America, is unsurpassed as an example of evolutionary migration.

(*b*) *Climate, climax and succession.*

A leading modern ecological concept is that of indicator vegetation, in which the climax community integrates the influence of a particular climate. Other more localized communities indicate conditions of soil and moisture, and a host of others occur wherever man has been active in disturbing cover and soil. The most significant and far-reaching application of the indicator method has been in connexion with the economic and social problems of the Great Plains. Initially it was assumed that the prevalence of short grass indicated a climate too dry for farming, and suited only to grazing. As a result the removal of nearly three-quarters of a million people was contemplated, and the abandoned farms returned to grass. Fortunately the premise is entirely erroneous and the conclusions correspondingly mistaken. The true climax of the Great Plains is mixed prairie, a mixture of medium and short grasses, in which the latter play an important part. Cumulative overgrazing removed the mid-grasses and enabled the short-grasses to cover pasture and range with a low sod. In dry years this simulates a climax and seems an indicator of an arid climate, but the ecological evidence is conclusive against this assumption. Mixed prairie is found wherever protection against grazing is afforded, but overgrazing will reduce it into short-grass, just as exclusion of the animal will restore it. Competition experiments confirm this, and the early accounts and photographs prove that the original vegetation was mixed prairie. Both from the rainfall relations and from the abundance of wheat grass in it, this community is an indicator of the fitness of the region in general for dry farming.

The type of crop to be preferred is suggested by the occurrence of wheat grass (*Agropyron Smithii*) as a dominant of the prairie, dropping out only in the southern part. It is not only a grass of the cooler climates, but it also has a water requirement higher than that of its associates, and prefers finer soils with more organic matter. In addition, it is a close relative of wheat, as the name indicates. Hence, it is an indicator not merely of cropping possibilities, but likewise of the suitability of a particular crop, namely, wheat.

The effect of drought, grazing and other influences on the dominant grass can be predicted, since the response of each grass dominant is regularly the same. Under drought the mid-grasses suffer more than the short-grasses and yield to them visibly; bunch grasses being less resistant than the sod-forming wheat grass. Since competition is again involved, the course of events under overgrazing is nearly identical. The sod-forming *Agropyron* prospers at the cost of such bunch grasses as *Stipa*, *Koeleria* and *Sporobolus*. The *Agropyron* then yields to the short-grasses, and of these, buffalo grass (*Buchloe*) gradually wins over grama (*Bouteloua*), partly by virtue of a denser sod but chiefly through rapid propagation by means of stolons. In the end, a cover of hardy buffalo grass may largely or wholly be replaced by one of weeds, which is valueless for forage, or for erosion control.

The ecological synthesis of factors, processes and methods of production and control, especially under conditions of drought and dust storms, has been embodied in a memorandum. This has been adopted as the basis of the solution of the human problems concerned in rehabilitation and conservation in the West.

ECOLOGICAL AND PHYSIOLOGICAL STUDIES IN THE BLOOMING OF OAT FLOWERS*

[Reviewer: A. R. Beddows]

The flowering processes in the oat (*Avena sativa* L.) and the effect on them of various factors have been studied in great detail. The conclusions made are based on a wealth of data which appear as tables in the text or in the appendix.

In order to facilitate the observation of the sequence of flowering in panicles the author fixed them on a wire gauze frame. Records were made every 15 minutes after the onset of blooming and the lemma of each open floret cut off in order to make it easier to recognize those which were to flower. Complete meteorological data were available.

1. Observation on the Blooming of Oat Flowers

The first flower to open was that in the apical spikelet of the main axis, and the order in which flowering was found to proceed is pictorially illustrated in the text. The secondary tillers always came into flower after the main shoot. In an entire plant the time taken to complete blooming varied from 29 to 31 days, but this period was reduced if the temperatures were high, and increased if low; in a single panicle flowering was completed in about eight days. The daily flowering period falls between 12.45 p.m. and 5.45 p.m. Of the 188 days on which observations were made, one proved exceptional in that on it flowering began at 9 a.m. Flowering is

*Misonoo, G. Ecological and physiological studies on the blooming of oat flowers. *J. Fac. Agric. Hokkaido.* 37. 211-337. 1936. (Sapporo, Japan.)

usually active for about an hour, generally between 2 and 3 p.m., and with the onset of blooming all the plants in the field come into flower more or less simultaneously. No plants were observed to come into flower before the critical temperature is reached. The author found that out of 231 possible flowering days in the three years 1927 to 1929, no flowering took place on 43 of them.

2. Ecological Studies on the Blooming of Oat Flowers

A. Environmental factors.

An intimate relationship exists between the temperature changes on any particular day and the occurrence of flowering on that day. The onset of flowering came when the difference between the temperature at about 8 a.m. and the maximum was from 3° to 8°C. and when the temperature fell 1° to 2.5° C. within an hour or two of the highest temperature. The range of maximum temperatures on flowering days was 15° to 32.8°C. (optimum 27° to 29°C.) and the range for the period of actual flowering 14° to 29.8°C. (optimum 24° to 26°C.). No blooming occurred when the temperature differences were less than those given above, even though the temperature was within the range necessary for blooming. The particular time of the day when blooming begins is correlated with the time the maximum temperature is reached ; if this is earlier than usual, blooming follows correspondingly earlier, and vice versa.

The relationship between humidity and flowering is also close. Blooming occurs when the difference between the morning humidity and the minimum is 10 to 20 per cent, and when the humidity increases by 3 to 7 per cent within an hour or two after the minimum is registered. If the difference in humidity is less than the above, flowering does not take place. The optimum humidity is 50 to 60 per cent, and that most satisfactory for the flowering period 60 to 70 per cent. The time of day at which flowering starts is correlated with the time when minimum humidity is recorded.

As flowering occurred on some rainy days, but not on others, rain itself had no direct influence on blooming.

There is also no direct relation between the force of the wind, and blooming and its time.

With regard to duration of sunshine, it was found that more sunshine usually meant more blooming, but instances were noted when flowering did not take place in spite of considerable sunshine. It is concluded, therefore, that there is no direct relation between sunshine and blooming.

Since panicles kept protected from sunlight flowered quite normally it is concluded that there is no relation between sunlight and blooming, on the day flowering is due to take place.

B. Control of blooming of oat flowers.

Experiments with panicles kept at different temperature levels showed that varying the temperature exerted control over blooming and the time of blooming.

Heads in the blooming stage, cut at different times and placed first in a higher temperature and then in a lower, were induced to flower 3 or 4 hours earlier or later than the natural time. Exposing cut panicles to a lower temperature than that obtaining at the time they are cut causes them to flower 2 hours earlier than those in the open. By suitably controlling the temperatures oats could be prevented from flowering or caused to flower on days when they would not normally do so.

Blooming was not controlled by artificially altering the humidity. Thus cut panicles kept under conditions of ordinary humidity, or in glass jars with dry or moisture-saturated atmospheres all reacted alike—if one lot flowered all were found to do so, or all the florets remained closed.

3. Physiological Studies on the Blooming of Oat Flowers

The opening and closing of the stomata on the dorsal side of the flag-leaf during the flowering stage was tested by means of cobalt chloride paper. It was found that the stomata opened with rising temperature and decreasing humidity, and closed when these conditions were reversed. When flowering occurred the stomata had started to close.

Panicles removed from the plant will continue to flower while they are supplied with sufficient water to keep them alive.

A study of the lodicules showed that they do not change until flowering begins, when their lower half swells considerably ; the lodicules diminish in size as flowering advances.

The lodicules contain only very slight traces of reducing sugar (glucose), but this increases rapidly in amount from the time the florets begin to open, reaching a maximum at the height of flowering.

Enzyme action in the lodicules is hardly recognizable prior to flowering, but it becomes active just before the florets open, and has ceased again by the time they have closed.

All these physiological changes, which form an integral part of the flowering process, are set in motion when the day temperature has reached the critical point which lies a few degrees below the maximum.

THE VEGETATION OF SOUTH AUSTRALIA

[Reviewer : Rosalind M. Whyte]

The Vegetation of South Australia, by Dr. J. G. Wood,*, Professor of Botany, University of Adelaide, is one of a series of handbooks dealing with the flora and fauna of Australia. Nine handbooks have already been published and four others are in course of preparation.

*Wood, J. G. The vegetation of South Australia. 25 × 16. pp. 164. 58 figs. 9 maps. Adelaide : 1937.

This book is the first of its kind to be published in Australia and describes the various plant communities which exist naturally in South Australia. The relationships of these plant communities to one another have been traced, and the factors which control their maintenance, such as climate, soil and the effects of animals, have been investigated.

In the initial chapter on " the units of vegetation and their characteristics," the fundamental ecological processes are explained and a key to the vegetation types of Australia is provided. This has five main vegetative types :

(1) Closed forest, (2) Open forest, (3) Scrub, (4) Grassland, and (5) Shrub steppe. All communities are regarded as related in a developmental succession which culminates in a well-marked climax association within any particular climatic zone. The causes may be biotic, physiographic or edaphic, of which the biotic is the most important. Particularly important from an economic standpoint are the results of fire and grazing on succession. Usually fire or severe grazing reverses the sere.

The outstanding ecological problems of a new country are the definition of the plant associations and their developmental inter-relationships. The system used for the study and analysis of the life-forms of the species is that developed by Raunkiaer. In a study of xeromorphy the sclerophyll leaf presents an interesting problem. The drought resistance of this type of leaf is best explained by its ability to withstand permanent wilting. This concept, of all the new criteria which have been proposed for xeromorphy, is by far the most important and far-reaching in its implications.

In chapter 3, entitled Climate, soils and vegetation, the main climatic, physiographic and soil boundaries of the state are discussed and illustrated. The importance of obtaining an expression which is an integration of the rainfall, temperature and humidity is of immense importance in semi-arid and arid regions. Such an expression is found in the Meyer ratio, which is the amount of rainfall divided by the saturation deficit. The high degree of correlation between the values for this ratio and the chief vegetation and soil types is remarkable.

There are five climatic plant formations in South Australia : 1. sclerophyll forest, 2. savannah forest, 3. mallee, 4. arid, and 5. desert.

An introduction to these vegetation regions is best effected by a study of vegetative succession in the coastal areas of the state where four distinct physiographic regions can be distinguished. These are marine meadow, dune, cliff and salt marsh. In the shallow waters of the Gulfs considerable areas of marine phanerogamic plants occur. The low sand dunes characteristic of the whole of the southern coast are first colonized by *Spinifex hirsutus*. This pure association is gradually replaced by *Scirpus nodosus—Mesembryanthemum aequilaterale* associes. This associes is eventually replaced by another dominated by *Olearia axillaris* which in the wetter areas culminates in *Casuarina stricta* consociation. The vegetation of the cliffs is difficult to define with regard to succession but eventually attains a climax type similar to that of the dunes. The successional trend for the first three vegetative divisions in the tidal salt marshes is the same in both the drier and the wetter regions, but eventually

two different climax associations are attained. In the south, with heavier rainfall, the climax is *Casuarina stricta* savannah forest, while in the north the climax is a saltbush community.

The savannah woodland formation is an open one with undergrowth which is predominantly herbaceous. Within the savannah zone there occur three climax associations: 1. *Casuarina stricta*, 2. *Eucalyptus odorata*, and 3. *E. leucoxylon*. The *Casuarina* phase frequently occurs between the sclerophyll forest on one side and the mallee on the other. In the *Eucalyptus odorata* associations the undergrowth was originally composed of *Themeda triandra* and *Danthonia penicillata*, but this has been modified considerably and the native flora ousted by introduced exotic grass species. This is also true of the *E. leucoxylon* association where the changes in vegetation due to close grazing are considerable. Today the chief grasses of these savannah woodlands are *Briza maxima*, *B. minor*, *Aira caryophyllea*, *Bromus unioloides*, *B. maximus*, *B. mollis*, *Festuca bromoides* and *Hordeum murinum*. In some areas the whole facies of the community has been changed by the colonization of *Olea europea*, *Rosa rubiginosa*, *Lavandula Stoechas*, *Crataegus oxycantha*, *Ulex europaeus* and *Rubus fruticosus*. The chief alien aggressors in the savannah woodlands have been grasses, rosette annuals and geophytes.

The most characteristic plants of the sclerophyll communities are eucalyptus and members of the Myrtaceae, Epacridaceae, Cyperaceae, and Phyllodineae At the present time those sclerophyll communities are limited to the podsolized soils. The climax community dominated by *Eucalyptus obliqua* is a high and fairly closed forest type. Grass species occur only as scattered individuals. The sclerophyll forest in the state is composed of a number of communities with a trend towards high forest of *Eucalyptus obliqua* in the wet areas, and towards mallee on the dry. A comparison of the plant communities of New South Wales and South Australia illustrates the interesting phenomenon which may be called ecological convergence. In general the same genera make up the sclerophyll forest of Australia, being represented by different species in the different regions. Generally speaking, sclerophyll communities are aggressive and rapidly recapture an area after disturbance; alien species are not therefore of such great importance in these communities.

In South Australia the limits of the mallee are fairly accurately defined by the 20-inch isohyet on the wetter and the 8-inch on the drier side. Both floristically and ecologically the mallee is an overlapping assemblage of plants connecting the wetter sclerophyll communities with the arid communities.

The arid communities are made up of two distinct types, the semi-desert scrub developed on rocky hills and sandhills, and the shrub steppe of the mature soils of the plains. These communities are found between the 8 and 5 inch annual isohyets. The importance of blowing sand derived from nearby deserts as well as wind action in these arid zones themselves is considerable. The balance between the vegetation and its environment is a delicate one in these areas and a slight disturbance has serious effects. The action of wind in this region has been aggravated by man and his

activities. Plateau areas carrying a dwarf shrubland of saltbushes have been grazed by sheep for 70 years. In adjoining mallee areas patches of unsuitable land were ploughed in the early days of agricultural settlement. Overstocked areas, whether paddocks or watering places, as well as the abandoned ploughed land, act as foci in which dust storms arise. The number of days per annum on which effective falls of rain occur is nine. Diurnal temperature ranges between 30° and 40°F. occur throughout the year.

The shrub steppe formation is important from an economic point of view, as it has been grazed by sheep for a considerable period. Its value as grazing land is the result of the nutritious character of the saltbushes (especially *Atriplex vesicarium*) and the blue-bushes. Approximately 20 per cent of the dry weight of the saltbush consists of protein ; as the salt content is high it is a natural concentrated food. This, together with its drought resistant qualities, makes it one of the most important plants in South Australia. Moderately heavy grazing is actually beneficial to a saltbush community, particularly if it is intermittent. The woody species in these arid areas are doomed to disappear in a short time unless seedlings which will readily regenerate, particularly after fire, are protected from rabbits, which in these areas are completely beyond control.

Subsequent chapters deal with the aquatic and swamp vegetation of the forest zone and the river, lake and swamp vegetation of the arid communities. In the last chapter the origin and migrations of the South Australian flora are discussed under the heads of native and alien plants. An index of the vernacular names of plants with their botanical equivalents forms an appendix to the volume, which is also supplied with a detailed coloured vegetation map of part of South Australia.

CONFERENCES

New Zealand Grassland Association

THE proceedings of the Fifth Conference of the New Zealand Grassland Association, held at Massey Agricultural College, Palmerston North, from August 18 to 21, 1936, were published in 1937 by the New Zealand Department of Agriculture.

The foreword is contributed by the Minister of Agriculture, W. Lee Martin, and the presidential address was delivered by Dr. A. H. Cockayne, Director-General, New Zealand Department of Agriculture, Wellington.

In this address, Dr. Cockayne reviewed the use of fertilizers in top-dressing pastures, the reorganization of the Plant Research Station in the Department of Agriculture, the export of grass and clover seeds, research relative to control of ragwort, and the relation between pastures and quality in products. The following summarizes the remarks made on the question of the export of grass and clover seeds.

There are many who are pessimistic that New Zealand could establish a large export trade in grass and clover seeds, particularly in Great Britain and the continent of Europe. At the present time the only seeds exported in any quantity are chewings fescue (*Festuca rubra* var. *fallax*), brown top (*Agrostis tenuis*) crested dogstail (*Cynosurus cristatus*) and white clover (*Trifolium repens*); when supplies of ryegrasses and red clover are short, however, and New Zealand has any surplus, a temporary trade is developed. This trade, however, is in what is called in New Zealand false perennial and also in Italian ryegrasses, these being the only types which can compete at the price offered. Both are recognized as extremely bad types and the question arises whether, in the interests of future development of superior types, the export of these inferior types should be allowed. New Zealand ryegrass is being given a bad name because of the shipment of this low grade stock. " The problem is admittedly difficult and rendered still more difficult by the rather scant praise Professor Stapledon has given to our certified type, declaring it to be about on a par with ordinary British commercial seed, while we look upon British commercial as very little better than our poor types. The fact that British seed importers are perfectly satisfied to obtain our bad ryegrass when their supplies are short, and show no interest either in the true perennial strain of Britain or our's, would indicate that the pasture seed position in Great Britain is distinctly bad, and that although the Welsh Plant Breeding Station has been in existence many years its influence is academic rather than commercial.

The following is a complete list of papers presented to the Conference. Abstracts of these will appear in a future issue of *Herbage Abstracts*.

International Grassland Congress Reports

The Joint Secretaries of the Fourth International Grassland Congress have had numerous enquiries regarding the Proceedings of the First, Second and Third Congresses. They wish to advise persons interested that these Reports are obtainable from the International Grassland Congress Association at the following prices :

RM. 2.50 (Verhandlungsbericht des 1. Kongresses).
„ 2.50 „ „ 2. „
„ 8.— „ „ 3. „

Orders and other correspondence should be addressed as follows :

Zentralstelle der Vereinigung Internationaler Grünlandkongress,
LEIPZIG,
Johannisallee 23,
Germany.

American Association for the Advancement of Science

A special issue of *Science*, the official organ of the Association (Vol. 87. No. 2249. Feb. 4. 1938), is devoted to the report of the one hundred and first meeting of the Association, held in Indianapolis from December 27, 1937, to January 1, 1938. Summarized notes are given on Sections A to Q, of which Sections G (Botanical Sciences) and O (Agriculture) are of particular interest to readers of this journal. Details of the papers read to associated societies are given elsewhere in this issue.

Section G. Botanical sciences. Subjects discussed included taxonomy as a field for research (J. M. Greenman), photoperiodism in relation to nutritional and other environmental factors (K. C. Hamner), and X-rays and cellulose, including recent contributions in the application of X-ray diffraction analysis to plant constituents (W. A. Sisson). Several papers were devoted to problems of leaf anatomy ; as a result of the comparative study of leaves of several species of trees and shrubs taken from different positions on the plants, G. H. Smith concluded that leaf size is determined more by cell number than by cell size, and that Lysenko's theory of a close correlation between the anatomy of the leaf and its position on the stem is not wholly tenable.

Four papers dealt with different aspects of vegetative propagation. The Physiological Section of the Botanical Society of America held a joint symposium with the American Society of Plant Physiologists and the American Society for Horticultural Science, on " Growth and development of meristems with special reference to reproduction." In the sectional meetings, contributions were made on the subject of dormancy, seed germination, light relations of plants and the role of vitamins B and C in growth. P. R. White presented the technique and results of his prize-winning research on the root pressure developed by pure cultures of tomato roots grown in nutrient solution.

Sixteen papers were presented on plant growth substances.

Section O. Agriculture. A symposium was held on " The role of minor element fertilization in economic plant production." Additional evidence was given of deficiencies of several of the so-called secondary and minor element plant nutrients, under commercial conditions, and their correction. It was concluded that too little is known at present about the problem as a whole to permit general recommendations for correcting many of these troubles. The section joined in the symposium on " Growth and development of meristems " already noted ; this " brought out the general thought that physiology and structure are inseparable and that workers in these two fields need a more common understanding."

Ecological Society of America

The twenty-third Annual Meeting of the Society was held at Indianapolis, Indiana, on December 28, 1937 to January 1, 1938, with the American Association for the Advancement of Science and other Societies (Botanical, Limnological and American Foresters).

The following are some of the papers presented :

The species-area curve. Stanley A. Cain, University of Tennessee.

Relation of secondary plant succession to soil erosion. Robert M. Warner, Iowa State College.

A quantitative study of the invasion of idle farm land by weed communities. Helen F. Barr and J. M. Aikman, Iowa State College.

An early " sand bowl " in Central Connecticut—cause and effect. Charles E. Olmstead, University of Chicago.

The vegetation of Mackinac Island, Michigan. An ecological survey. J. E. Potzger, Butler University.

The revegetation of some alkali flood plains adjoining the North Platte River, Garden County, Nebraska. Etlar L. Nielsen, University of Arkansas.

California grasslands. A. G. Vestal, University of Illinois.

The effects of deer browsing in the forests of Pennsylvania. John C. Kase, Purdue University.

The effect of livestock grazing on the Indiana farmwoods. Daniel DenUyl, Purdue University.

Acridian plant and soil relations. F. B. Isely, Trinity University.

An ecological study of the vegetation of the Upper Columbia Plateau. Rexford F. Daubenmire, University of Idaho.

Plant associations and their succession in the Ozarks of Missouri. Julian A. Steyermark, Field Museum of Natural History.

A botanical survey of Oakland County, Michigan. Mrs. Marjorie T. Bingham, Cranbrook Institute of Science, Bloomfield Hills, Michigan.

The response of corn to drought conditions. Roy A. Bair and J. M. Aikman, Iowa State College.

Relation of corn yield to rate of growth data and available soil moisture. J. M. Aikman, H. F. Eisele, R. A. Bair, Iowa State College.

A quantitative study of roots and root-hairs of *Poa pratensis* and *Secale cereale* in upper soil levels. Howard J. Dittmer, State University of Iowa.

The ecology of some rare plants. Robert F. Griggs, George Washington University.

Some effects of modified illumination on the flowering of Gramineae. Paul Weatherwax, Indiana University.

Oahv vegetation : its past, present and future. Frank E. Egler, New York State College of Forestry.

The biotic areas of Oklahoma. T. H. Hubbell, University of Florida, and W. F. Blair, University of Michigan.

Studies on the ecology of secondary communities in a deciduous forest area. William C. Van Deventer, St. Viator College.

Some aspects of Arctic-Alpine ecology on the origin of species. Walter Kiener, University of Nebraska.

Mangrove vegetation and land building in Florida. John H. Davis, Jr., Southwestern College.

American Society of Plant Physiologists

The Fourteenth Annual Meeting of the Society was held in Indianapolis, Indiana, on December 28, 29 and 30, 1937 in affiliation with the American Association for the Advancement of Science (President of Society : O. F. Curtis, Cornell University, Ithaca, N.Y.)

The following were among the papers presented :

Phosphorous fractions in chloroplasts and leaves. Sam Granick, University of Michigan.

Photosynthesis and the living state. Ondess L. Inman, Antioch College.

Increase in weight by plants hermetically sealed within pyrex flasks and exposed to sunlight. E. A. Spessard, Hendrix College.

Taxonomy as a field for research. J. M. Greenman, Missouri Botanical Garden.

The correlative effects of environmental factors on photoperiodism. Karl C. Hamner, University of Chicago.

X-ray diffraction analysis and its application to the study of plant constituents. Wayne A. Sisson, Boyce Thompson Institute.

Structural problems in the meristem. E. W. Sinnott, Barnard College, Columbia University.

The relation of polymerization reactions to meristematic development. W. E. Loomis, Iowa State College.

The influence of photoperiods upon the differentiation of meristems and the blossoming of biloxi soybeans. H. A. Borthwick, U.S. Horticultural Station, Beltville, Md.

The influence of foliar and meristem activity upon floral development. W. F. Loehwing, University of Iowa.

Induced parthenocarpy. F. G. Gustafson, University of Michigan.

Meristems and fruitbud formation in relation to general horticultural practice. J. H. Gourley, Agricultural Experiment Station, Wooster, Ohio.

Floral development of certain species as influenced by X-radiation of buds. Edna L. Johnson, University of Colorado.

Relation of CO_2 to the effect of light on the E.M.F. of *Valonia ventricosa*. Gordon Marsh, State University of Iowa.

Polar and reversible inhibition of growth in the root tip by an applied electric potential. E. J. Lund and R. F. Mahan, University of Texas.

Differences between the early stages of development in vernalized and non-vernalized wheat varieties. H. G. du Buy, University of Maryland.

The modification of photoperiod responses by temperature. R. H. Roberts and Burdean E. Struckmeyer, University of Wisconsin.

Induction of reproduction and inhibition of growth in their relation to photoperiodism. A. E. Murneek, University of Missouri.

Growth of Avena coleoptile and first internode in different wave-length bands of the visible spectrum. Earl S. Johnston, Smithsonian Institution.

Vitamin B_1 and the growth of roots. The relation of chemical structure to physiological activity. James Bonner, California Institute of Technology.

Factors other than auxin affecting root formation. William C. Cooper, Bureau of Plant Industry, Pomona, California.

Growth of pollen tubes in cotton. J. C. Ireland, Oklahoma Agricultural and Mechanical College.

The chemical determination of ethylene in plant tissues. R. C. Nelson, University of Minnesota.

Ceric sulfate for determining plant sugar values. C. G. Barr, Colorado State College.

The carbohydrates in the roots of *Lepidium repens*. C. G. Barr, Colorado State College.

Carbohydrates of wheat leaves. G. Krotkov, Queens University, Kingston, Ontario, Canada.

Corn kernel parts as indicators of hybrid vigor. M. E. Paddick, Iowa State College.

Leaf temperatures. R. H. Wallace, Connecticut State College, and H. H. Clum, Hunter College.

Transpiration of the awns of wheat. Hugh G. Gauch, University of Chicago, and Edwin C. Miller, Kansas State College.

The effect of centrifugal force on certain plant cells. F. M. Andrews, Indiana University.

A molecular basis for a structural conception of protoplasm. O. L. Sponsler, University of California.

A method for maintaining alive juicy plant tissues after immersion in liquid air. Basile J. Luyet and Gregory Thoennes, Saint Louis University.

The accumulation of aluminum and manganese in plants in relation to soil reaction. G. M. Shear, Virginia Agricultural Experiment Station.

The use of tank culture in physiological studies of corn. J. D. Sayre and V. H. Morris, Ohio Agricultural Experiment Station, and Cereal Crops and Diseases, U.S.D.A.

Turbulence, convection and other physical factors in relation to transfer of solutes. E. S. Reynolds, Washington University.

Reversible inhibition of water absorption of different root regions in single, intact and excised roots. Hilda F. Rosene, University of Texas.

Translocation gradients in maize. W. E. Loomis, Iowa State College.

The relation of cabbage hardiness to bound water, unfrozen water, and cell contraction when frozen. J. Levitt, McGill University.

American Phytopathological Society

Among the papers accepted for presentation at the twenty-eighth annual meeting of the Society, at Indianapolis, Indiana, on December 27 to 30, 1937, were the following :

Pythium de baryanum and other *Pythium* species cause alfalfa seedling damping off. W. F. Buchholtz and Clifford H. Meredith.

Smut in latent buds of sorghum. G. N. Davis.

Buckwheat as a factor in the root rot of conifers. E. J. Eliason.

Alkaloids isolated from plants resistant to *Phymatotrichum omnivorum* and their influence on growth of the fungus. Glenn A. Greathouse.

Further determinations of the carbohydrate-nitrogen relationship and carotene in leafhopper-yellow and green alfalfa. H. W. Johnson.
Crotalaria mosaic. H. W. Johnson and C. F. Lefebvre.
Effect of prolonged storage of treated seed corn. Benjamin Koehler.
Seed treatment tests with crown-injured corn. Benjamin Koehler.
Differentiation of five mosaic viruses of legumes. H. T. Osborn.
Observations on nematodes of buffalo grass and sorghum. Gertrude Tennyson.
Two strains of cucumber virus on pea and bean. O. C. Whipple and J. C. Walker.
The effect of boron nutrition on the susceptibility of some plants to powdery mildews. C. E. Yarwood.

"Perhaps the most interesting trend in phytopathological research, disclosed by as many as ten different papers, was the present-day emphasis on growth-promoting and growth-inhibiting substances and their influence on the relations between host plants and parasites, which affect the course of the disease process, and the phenomena of aggressiveness on the one hand and susceptibility or resistance on the other." (*Science*. 87. 108-9. 1938.)

Association of Scandinavian Agricultural Investigators

This Association (Nordiske Jordbrugsforskeres Forening) will hold its next Congress at Uppsala from July 4 to 8, 1938. The Congress will be organized in the same way as in previous years. A provisional list of papers to be contributed is to be found in *Nordisk Jordbrugsforskning* 1937. Pt. 5-6. pp. 219-24.

One main excursion will be to Norrland.

Another main excursion, specially intended for those interested in grassland and stock farming, will proceed south, visiting the Institute of Animal Husbandry at Wiad, then on to Östergötland, and possibly continuing to south Sweden.

In addition there will be an excursion for plant pathologists to Gothland and possibly to Öland.

The soil scientists and those interested in cultural technique contemplate a three days tour to Västmanland, Nerike and Västergötland.

It is hoped to send out the final agenda in March and to be able then to furnish a complete plan of the various excursions.—R.P.J.

ANNOTATIONS

GERMANY (43)

Bavarian Institute for Crop Production and Plant Pathology, Munich.

An historical account of the work of the Bavarian Institute for Crop Production and Plant Pathology (Bayer. Landesanstalt für Pflanzenbau und Pflanzenschutz), Munich, since its foundation in 1902, is presented in *Prakt. Bl. Pflanzenb.* 15. 113-98. 1937. Pages 113-42 are concerned with the organization and with salient facts in the history of the Institute, the administrative and laboratory work of which was transferred to larger premises in 1936 ; pp. 142-87 with achievements and work in progress ; and a list of the Institute's publications from 1927-37, comprising 360 references, is given on pp. 187-97.

Of the work which is briefly outlined, reference may be made to the following activities : a study of soil sickness in relation to the growing of legumes, begun in 1926 (pp. 146-8) ; study of the effects of manganese and other trace elements (pp. 150-1) ; biological and physiological studies of *Trifolium pratense* with special reference to the soil sickness problem (pp. 156-7) ; special physiological studies concerned, for example, with the constitution of red clover, of the soybean, and with physiological differences between the sweet lupin and the bitter lupin and their relative liability to fungous disease [p. 158, see also Merkenschlager, *Herb. Abstr.* 6. 90. 1936] ; studies of parasitic diseases of red clover in connexion with the soil sickness problem (pp. 160-1) ; manurial treatment in reference to the chemical composition of hay (pp. 177-8) ; the testing and certification of seed (number of samples 6,918 in 1927, 11,613 in 1936, pp. 178-82) ; the promotion of ensilage (pp. 184-7).

Experiment Farm, Nederling.

The Nederling Experiment Farm, belonging to the Bavarian Institute of Crop Production and Plant Pathology (Bayer. Landesanst. f. Pflanzenbau u. Pflanzenschutz), Munich, is situated on gravelly, humus, slightly loamy sand, reaction practically neutral, near Munich ; average rainfall 817.4 mm., elevation 513.8 m. above sea level. A brief report of its present activities is presented in *Prakt. Bl. Pflanzenb.* 15. 1-12. 1937, wherein a large number of experiments are listed under the following heads.

A. Long duration experiments with different rotations.

Five experiments here are concerned with the manurial treatment of different cereal-legume-root rotations. One experiment is a trial of fourteen legume species,

the time for which they have been grown in the same place varying from one to twelve years.

B. Experiments on areas which are differently used every year.

1. Cereals. Many varietal and manurial trials, experiments in different forms of cultural treatment, times of sowing, planting distance, disinfection, etc.

2. Rape. Five experiments to test varieties, manurial treatment, times of sowing, planting distance and seeding rates.

3. Miscellaneous crops. Experiments include the following: Lupins, trial of inoculation with and without N; and manurial trial (20 kg. N, 60 kg. P, and 120 kg. K per hectare, *Lupinus luteus* and *L. angustifolius*). Soybeans and *Ornithopus sativus*, inoculation and manurial trial.

5. Fodder beet. Five manurial trials.

6. Maize, marrow stem kale, and miscellaneous forage crops. Maize, one variety and four manurial trials. Marrow stem kale, two manurial trials. Miscellaneous: trials of sunflowers, millet, Sudan grass, buckwheat, turnips, etc., as catch crops. Trial of potassium manuring of *Trifolium incarnatum* and of the "Landsberg mixture" (20 kg. *T. incarnatum*, 20 kg. *Lolium italicum* and 30 kg. *Vicia villosa* per hectare); and a trial of nitrogenous fertilizers applied to the Landsberg mixture.

7. Study of soil sickness in connexion with the growing of legumes, *Trifolium pratense* in particular. The principal fodder legumes are grown for varying periods (a) in succession, or (*b*) after other legumes, and these trials are combined with studies of nutritional requirements, the effects of different fertilizers, of the trace elements, farmyard manure, etc., and with studies of the problem as affected by soil cleaning, green manuring, cover crops, source of origin, time of mowing. A large number of plots are devoted to this investigation.

8. Meadowland. (a) Improvement with organic and mineral fertilizers, different times of mowing; (b) Compost trial; (c) Seed production trial, *Festuca rubra* and *F. pratense*, with and without cover crop, combined with a manurial trial.

9. Five tests of the after-effects of farmyard and humus manures on various crops including wheat, oats, the Landsberg mixture, and turnips.

C. Phytopathological experiments.

These include a study of disease resistance in various clover species under different manurial treatment, and experiments in the disinfection of cereals.

D. Pot trials.

These include a trial of soil consistency, manurial treatment and water supply in connexion with *Lolium italicum*; experiments concerned with the Farm's study of soil sickness under legumes (described above), and in particular investigations on the chemical, toxic, and microbiological principles governing soil sickness; physiological studies of the nutrition of *Trifolium pratense*; experiments concerning the influence of molybdenum upon the nitrogen nutrition of *T. pratense*, in pots and in water cultures; and trials of newly obtained legume nodule bacteria.

E. Pot trials (phytopathological).

The following are concerned with legumes : 7. Nutritional and variety trials and experiments in different methods of soil treatment, with reference to the control of root diseases in legumes. 8. Experiments in the control of clover rot. 9. Physiological experiments concerned with red clover.—G.M.R.

HUNGARY (439.1)

Grasslands of Hungary.

In a paper presented to the Eleventh World Dairy Congress held at Berlin in 1937, an account was given by K. T. Kolbai, Keszthely, of the grasslands of Hungary and of the importance of resowing them (*Wiss. Ber. XI. Milchw. Weltkongr. Berl.* 1. 115-8. 1937) ; and in another paper J. von Piukovich, Budapest, presented a study of the fodder value of the grazings in the Great Hungarian Plain, with special reference to the production of milk (*ibid.* 1. 157-61. 1937).

Kolbai, K. T. Grasslands of Hungary. The causes of the wide-spread deterioration of the grasslands of Hungary, mainly permanent pasture or permanent hay land, are outlined. They include the following : the ploughing up of grassland for grain crops and its subsequent abandonment with a view to natural regrassing—this has been productive of large areas of weed-infested waste land ; irrational use of the remaining grassland, early herbage wasted, grazings overstocked, hay cut too late, over-drainage of hay land. Some decades ago the ploughing up of communal pastures was prohibited and measures for their improvement were legally enforced, but this action was found insufficient, and, to meet the danger with which the stock-raising and dairy industries of Hungary are threatened, three Grassland Associations have been formed. They are centred respectively at Budapest, Magyar-Ovar, and Keszthely, and between them serve the interests of grassland improvement for the whole country, the Hungarian Ministry of Agriculture exercising a general supervision. The activities of the three Associations, which are for the most part educational and advisory, have brought to light the fact that practically all the old grassland in the country requires ploughing up and resowing if it is to be usable for modern grassland farming, and undoubtedly one of the most important tasks confronting the Associations is that of persuading the farmers of the necessity of this course of action and assisting them in carrying it out. Animals fed in the stall on forage crops from the field can never be so healthy, nor can the animal products, milk in particular, be so satisfactory for human consumption as under natural conditions of grazing in the open. In support of this, attention is drawn to the higher vitamin content of milk from cows on pasture. Modern grassland management is an indispensable factor in the ensuring of adequate supplies of home-grown fodder. At the same time it is

necessary also to increase the attention devoted to the growing of field forage crops, since in Hungary their place can never entirely be taken by grassland, especially in the more arid parts of the country.

Piukovich, J. von. Great Hungarian Plain. Up to the nineteenth century the chief economic value of the great low-lying Hungarian Plain, the Alföld, lay in a nomadic form of stock-raising which was highly profitable and for which this region was particularly suited. An agricultural revolution took place towards the end of the nineteenth century, however, when drainage schemes were set on foot and the great increase in the growing of cereals resulted in the proportion of arable land being increased by more than 42 per cent, this increase taking place at the expense of the most valuable pastures and hay land. After the war the proportion of arable land was still further increased, and the production of natural fodder still further reduced in quantity and quality. The grazings of the Alföld today occupy approximately 420,000 hectares, and are mostly managed on a co-operative or communal basis. They vary in size from ten hectares to the characteristic heaths or rough grazings ("Pusztas") which may cover up to 50,000 hectares. Soil is very diverse in nature; temperature on the whole continental, but variable; average annual precipitation 500 mm., unfavourably distributed (little rain in July and August); the plain is subject to much wind, especially from the west; the natural herbage is rather poor in species (typical grasses, *Festuca pseudovina, Cynodon dactylon, Agrostis alba*; legumes, *Trifolium repens, T. pratense, Lotus tenuifolius*, L. *corniculatus, Medicago lupulina, M. falcata*; many weeds). Conditions are nevertheless not particularly poor for grass farming, and since 1926 the Ministry of Agriculture has taken steps for the improvement of the fodder value of the Alföld grazings through the provision of drinking facilities for the cattle, the planting of trees as shelter belts against the prevailing winds, the appointment of inspectors, and educational work. The Grassland Association for the Alföld, an integral part of the grassland movement set on foot in 1929, is continuing to work along these lines and is also aiming at increasing the proportion of arable land devoted to the growing of forage crops. Data are given which demonstrate that the average fodder value of the grazings is such as to make it worth while to develop them. Milk production from cows grazed on pasture is much greater than that from stall-fed cows (in May, 1935 and 1936, more than 280 per cent), and at least 50 per cent cheaper. It is considered that the division of the Alföld grazings into paddocks by means of wire fencing would not be profitable. One of the most urgent questions at present is that of the production of home-grown grass seed for resowing, and the area devoted to this purpose is increased annually.

[See also Kolbai, K. T. The sowing down of grassland in an arid climate. *Rep. Fourth Int. Grassl. Congr. Gr. Brit.* 132-9. 1937 (article in German, English summary, pp. 138-9); and Piukovich, J. von. Hungarian grassland farming and the grassland movement. *Ibid.* 140-4. 1937 (article in English, German summary, pp. 143-4.)]—G.M.R.

NETHERLANDS (492)

Report on Agriculture.

The Report on Agriculture in the Netherlands in 1936 (*Versl. Dir. Landb., 's-Grav.* 1937. No. 2), notes that the weather conditions were extremely good for grass growth ; an abundant supply of herbage was available throughout the whole of the grazing period, and good crops of high quality grass and clover hay were obtained. Although lucerne and other legume crops of arable land suffered in the south-west and south in consequence of night frosts and of clover rot which had attacked the fields in the winter of 1935, the first cut gave on the whole a good crop of high quality. The area devoted to the growing of pulse was increased by approximately 4,000 hectares, chiefly owing to the increased cultivation of field beans. Milk production was abundant on account of the good grass growth, but unprofitable owing to the low price of milk and the high price of concentrates.

Seed crops of Western Wolths ryegrass (Groningen), white clover (Friesland), and red clover (in the south) were poor. In the case of the Western Wolths ryegrass, it is noted that the failure was probably due to the fact that the crops were allowed to stand too long in stooks, whereby much seed was lost.

Reclamation work has included the reclamation of large areas of grassland from marsh and waste land in the various Provinces. From the new Wieringermeer land it is reported that although harvests were on the whole poorer than in the previous year, grass growth was abundant. Lucerne exhibited vigorous growth, but the stands were poor on account of the heavy cover crop of the previous year, and many fields were fallowed after a moderate crop had been obtained from a part of the first cut only. Great importance is attached to the inoculation of legume crops, and cultures have been prepared and distributed for the inoculation of over 6,000 hectares.

—G.M.R.

FRENCH SUDAN, The Niger (662.1)

Research by Office of the Niger.

The agricultural research conducted in 1936 by the Office of the Niger is reported in *Rev. Bot. appl.* 17. 624-32. 1937. Millets (used for fodder as well as for human consumption) and ground nuts (*Arachis hypogaea*) have played a prominent part in rotation experiments in progress for several years at Banankoro. Trials of *Dolichos lablab* prove this plant to be of value for late cultivation (sown in October or early November) , the green weight for fodder, the grain for human consumption : cultural methods and water requirements are still being studied. Mass selection of

indigenous varieties of millet has resulted in the production of valuable homogenous types. Trials of maize from the U.S.A. have indicated that four are worth retention as adapted to the climate of the Niger. Two early indigenous maize varieties are to be developed. Varieties of *Arachis hypogaea* suitable for different regions are being reproduced and give satisfactory yield. Some new forage plants have been introduced. Of plants under trial, the following are retained as likely to give interesting results when grown on a large scale : some sorghum species for ensilage (honey drip sorghum, sugar drip sorghum), a *Tricholaena* species, *Chloris gayana*, *Pennisetum purpureum*, *Andropogon sorghum* var. *Sudanensis*, and four local grasses of which the native names only are given ; and some legumes which include *Crotalaria striata*, *Dolichos lablab*, and velvet beans (*Mucuna* or *Stizolobium*). Green manures are considered of great importance for the rice-fields, and a study of how best to employ them is being made. *Crotalaria retusa* is the plant most generally employed for the purpose.—G.M.R.

BRAZIL (81)

Department of Agriculture.

A brief outline of the activities of the Department of Agriculture for the year 1936, included in the address of the President of the Republic to the National Congress in May, 1937, is reported in the *Bol. Minist. Agric., Rio de J.* 26. No. 4-6. 83-122. 1937. Agrostological work under the supervision of the Institute of Animal Biology included trials of six varieties of *Melinis minutiflora*, of which the most cold-resistant, capable of growing at an elevation of 1,000 m., is being reproduced for seed. A special study was made of the legume *Meibomia* (*Desmodium*) *discolor* ; some varieties have emerged which are characterized by earliness, leafiness, and the ability to give a large number of cuts. Other *Meibomia* (*Desmodium*) species are under observation. In view of the insufficient space at the disposal of the Agrostological Department of the Ministry, it is hoped to carry out similar trials in the various States.—G.M.R.

ARGENTINE REPUBLIC (82)

Tucuman Agricultural Experiment Station.

The annual report of the Director of the Tucuman Agricultural Experiment Station, Dr. W. E. Cross, appears in *Rev. industr. agric. Tucuman.* 27. 5-67. 1937. It covers the work of the year 1936, and although mainly concerned with the cultiva-

tion of sugar cane, citrus fruits, cotton, etc., forage and green manure crops have also received attention.

Green manures. Of various legumes tested for use as green manures in citrus plantations, the following, in order of value, have been found most useful : *Vigna sinensis*, Tucuman bred Strain No. 22 ; *V. sinensis*, " Victor " and " Whippoorwill " ; *Desmodium tortuosum* ; *Stizolobium deeringianum* ; *Phaseolus mungo* ; *Canavalia ensiformis*. The superiority of the Tucuman cowpea No. 22 is due principally to its greater and more sustained vigour. *Desmodium tortuosum* is very erect and of dense growth, and has the advantage of reseeding itself annually from the abundance of seed produced in the autumn.

Soybeans. A trial of twenty-one varieties was conducted with a view to selecting those of most value for conditions in Tucuman, where the crop is not yet in general use. In addition to already acclimatized soybeans, varieties from Japan, Poland, and the United States were included. A deficiency of soil moisture at the time of sowing affected production adversely.

Forage plants. A collection of seed of twenty-six different classes of forage plants received from Brazil was under trial in 1936.

The distribution of seed included that of cowpeas (7,219 kg.), Rhodes grass (2,422 kg.), clover No. 9, and Sudan grass.—G.M.R.

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